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January 1, to June 30, 1914

Explanatory Note

Illustrated articles are marked with an asterisk (*), book notices by a dagger (†), inquiries by a double dagger (‡). The cross references condense the matter and assist the reader, but are not to be regarded as complete or conclusive. So, if there were a reference from "Boiler" to "Furnace" and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross reference. A reference from "Oil" to "Lubricating" would apply equally to "Lubrication," "Lubricator," etc. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

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POWER

Vol. 39 NEW YORK, JANUARY 6, 1914 No. 1

1913
1914
LARGEST WATER POWER PLANT IN THE WORLD
LARGEST STEAM TURBINE UNIT YET BUILT
LOWEST STEAM CONSUMPTION OF A NON-CONDENSING ENGINE
LARGEST DIRECT-CURRENT GENERATOR
FIRST AMERICAN LOCOMOBILE
LARGEST GAS ENGINE IN AMERICA
LARGEST TURBINE-DRIVEN CENTRIFUGAL PUMP
LOWEST STEAM CONSUMPTION OF A PRIME MOVER
LARGEST STEAMSHIP
POWER

Can He Beat This Record?

Use of an Indicator in Setting Engine Valves

By Charles Munson

SYNOPSIS—Showing the importance of proper valve setting of a compound air compressor, also the effect on the indicator diagrams with different adjustment of the valves. The saving in steam consumption with properly adjusted valves over that used with improperly set valves is also shown.

⁂

All of the accompanying indicator diagrams were taken while setting the valves on a cross-compound, two-stage air compressor. As the load was fairly constant they clearly show what effect the various adjustments have on the steam distribution in the cylinders; also, the effect proper valve adjustment has on the steam economy.

This compressor had an 18 and 30 by 32-in. steam cylinders and 26x15-in. air cylinders. The speed was about 60 r.p.m. Each cylinder had a 2⅝-in. piston rod passing through both heads. The valve-gear was a modified form of the Myers gear with riding cutoff valves. Both the main and auxiliary valves were driven by eccentrics, cast solid with each other. The cutoff could be adjusted to suit the load, while the compressor was in operation, by turning a handwheel on the cutoff valve rod. The steam pressure was 130 lb.

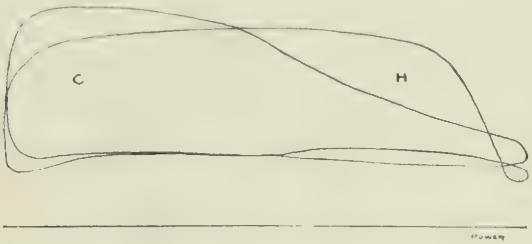


Fig. 1

In Figs. 1 and 2 are shown the condition of the valve setting in the high- and low-pressure cylinders, respectively, before any adjustments were made. Referring to Fig. 1, the head-end diagram shows very late admission and full steam pressure is not admitted to the cylinder until the piston has traveled approximately 20 per cent. of its forward stroke. This also accounts for the negative loop at the beginning of the admission line. Cutoff does not occur until nearly the end of the stroke, the auxiliary valve being so adjusted as to be useless. The crank-end diagram is better, although far from being good. The principal fault is a late admission.

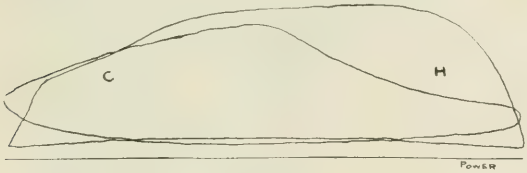


Fig. 2

Initial steam pressure on the head-end diagram is only 90 lb. per sq.in. and on the crank-end, 100 lb., although the boiler pressure was 130 lb. per sq.in. The difference in pressure in the two ends of the cylinder was due to the fact that the head-end valve did not open wide enough to permit the pressure to build up in the cylinder above 90 lb. The 30-lb. drop in pressure between the boilers and the cylinder occurred because the speed of the compressor was controlled by the throttle and not by adjusting the cutoff. Although cutoff occurs much earlier in the crank end than in the head end the indicated horsepower of both ends of the cylinder is the same. Comparing the total indicated horsepower of the high-pressure cylinder with that of the low-pressure cylinder the former is doing more work because too low a receiver pressure was being carried.

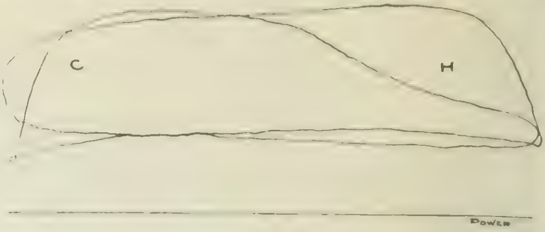


Fig. 3.

Adjustment was first made to equalize the events in the two ends of the high-pressure cylinder. The main valve rod was shortened two turns, making the head-end admission earlier and the crank-end admission later. Fig. 3 shows the result of this adjustment. The negative loop of Fig. 1 has disappeared and full admission pressure occurs at about 12 per cent. of the stroke. A small negative loop has appeared at the beginning of the admission line at the crank end and full admission pressure does not occur until approximately 15 per cent. of the stroke.

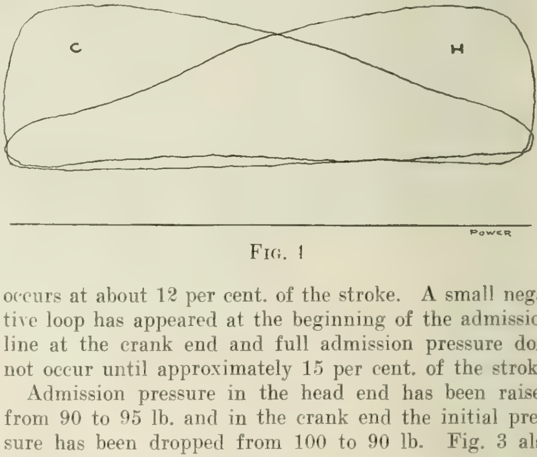


Fig. 1

Admission pressure in the head end has been raised from 90 to 95 lb. and in the crank end the initial pressure has been dropped from 100 to 90 lb. Fig. 3 also shows that the valve rod was shortened a little too much and its length was increased one-half turn before the diagrams shown in Fig. 4 were taken. To make all events in both ends of the cylinder occur earlier the eccentric was advanced about 2 in.

As both the main and cutoff eccentrics are cast in one piece, both eccentrics were advanced the same amount. The cutoff valves were then adjusted to equalize the cutoff and the diagrams shown in Fig. 4 were taken. They show a much earlier admission and release than those in Fig. 3, and that some compression has been added. The load between the two ends has been nearly equalized and the initial pressure raised to 100 lb. on both ends. The peculiar expansion line of the crank-end diagram is due to a leaky valve, caused by changing the travel of the valve and taking the indicator diagram before it had worn down to a tight seat.

After advancing the eccentric ½ in. more the diagrams in Fig. 5 were taken. In getting these results no changes were made in the low-pressure valve setting nor was the cutoff in the high-pressure cylinder made earlier. After adjusting the low-pressure valves, the low-pressure cutoff was made earlier, and the receiver pressure was increased, the low-pressure cylinder doing a larger proportion of the work. At the same time the work done in the high-pressure cylinder was decreased. The throttle was then opened wide and the high-pressure cutoff occurred earlier, thereby keeping the speed of the machine constant.

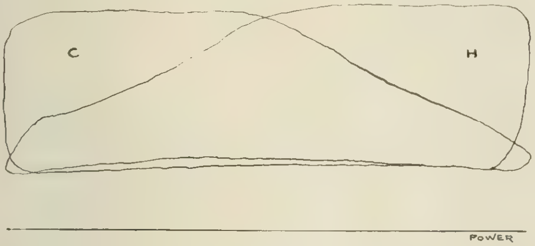


Fig. 5.

Fig. 6 shows the results obtained. These diagrams were taken after all adjustments were made. The initial pressure has been increased to 120 lb. and the back-pressure raised to 37 lb. The indicated horsepower has been reduced from 114 to 108.91. In Fig. 2 is shown the low-pressure diagrams before adjusting the valve setting. Admission and release are both late and the crank-end cutoff is much earlier than in the head end. The low-pressure valve rod was shortened to equalize events, and the eccentrics advanced about 1 in. to make all events occur earlier. After adjusting the cutoff valves, diagrams were taken, as shown in Fig. 7.

Admission and release are still late; more so on the head end than on the crank end. Cutoff is also later on the head end than on the crank end. The valve rod was shortened about three-quarters of a turn and the eccentric advanced ½ in. more. The diagrams shown in Fig. 8 were then taken.

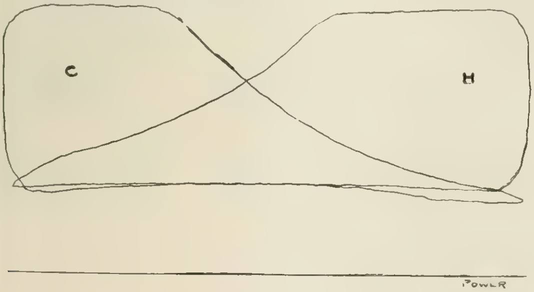


Fig. 6

These adjustments have raised the initial pressure about 2 lb., but more work is being done in the high-pressure cylinder than in the low. The cutoff valves were further adjusted and the cutoff was made to occur earlier until the receiver pressure was raised to 37 lb. per sq.in. Diagrams shown in Fig. 9 were then obtained.

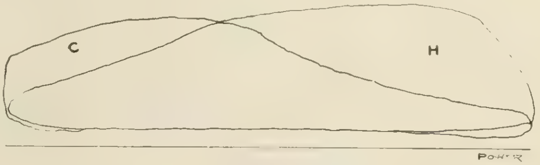


Fig. 7

The speed of the compressor has been reduced from 60 to 55 r.p.m., although the total indicated horsepower is practically the same as at first. Before the diagrams shown in Figs. 6 and 9 were taken, the air valves were cleaned and new piston rings put in both air pistons. This so reduced the leakage that the speed could be dropped 5 r.p.m. and still carry the load.

In order to show more clearly the effect of these various changes, Figs. 1, 2, 6 and 9 have been combined in Fig. 10. The clearance was found to be approximately 7 per cent. for each cylinder. The cylinder ratio is 30^2 to 18^2 or 2.77. The total volume of the high-pressure cylinder referred to the low-pressure cylinder is

$$(1 + 0.07) \div 2.77 = 0.386$$

and

$$0.386 - 0.07 = 0.316$$

In other words, the end of the high-pressure diagrams should be plotted at 31.6 per cent. of the low-pressure diagrams. Dividing the high-pressure volume by the cylinder ratio 2.77, and drawing all four diagrams to the same pressure scale, Fig. 10 is obtained. Dotted lines show the diagrams taken before setting the valves and the full lines indicate those taken after all adjustments had been made.

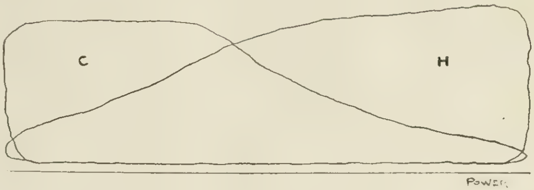


Fig. 8

Particular attention is called to the increase in initial pressure in the high-pressure diagrams, decrease in the drop in pressure through the receiver, higher receiver pressure and lower release pressure in the low-pressure cylinder. This last point shows that the expanded steam has been carried further and consequently better economy has been obtained.

The following figures will give an approximation of the saving which has resulted by having the valves properly set. At point *A*, Fig. 10, which is 90 per cent. the head-end stroke, and 90 per cent. of the volume of the low-pressure cylinder plus the clearance, 7 per cent., makes a total of 97 per cent. if the low-pressure cylinder is filled with steam at 13.3 lb. gage or 28 lb. absolute. This steam contains more or less moisture, due to cylinder condensation. However, it is impossible to determine what the percentage of moisture is from the ordinary indicator diagram, so it is assumed to be dry at this point. This assumption will not affect the actual saving as the same assumption is made in calculating the steam consumption after setting the valves. It will make the steam consumption per indicated horsepower lower than actual, however.

From the steam tables it is found that the weight of a cubic foot of dry steam at 28 lb. per sq.in. absolute is 0.068 lb. The volume of the low-pressure cylinder is 12.99 cu.ft. after deducting the volume of the piston rod, which is $2\frac{5}{8}$ in. in diameter there remains,

$$0.97 \times 12.99 = 12.6\ cu.ft.$$

The total weight of steam in the head end of the cylinder up to point A is,

$$12.6 \times 0.068 = 0.8568\ lb.$$

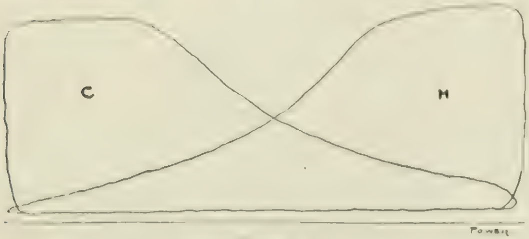


Fig. 9

at the beginning of the stroke B, the clearance space is filled with steam at 1.5 lb. gage or 16.2 lb. absolute. The weight per cubic foot of dry steam at this pressure is 0.041 lb. and the volume of the clearance is 7 per cent. of 12.99 or 0.91 cu.ft. The total weight of steam in the clearance then is

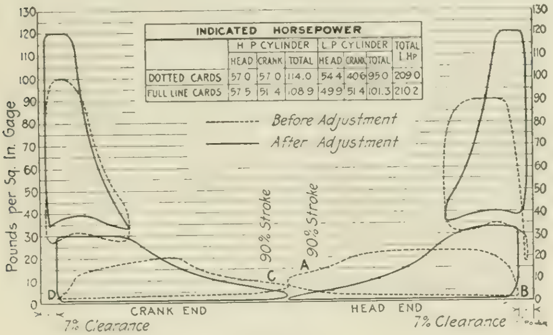
$$0.041 \times 0.91 = 0.0373\ lb.$$

This steam is already in the cylinder when the admission valve opens so that the only steam admitted at the head-end stroke is the difference between that shown at A and B or

$$0.8568 - 0.0373 = 0.8195\ lb.$$

In a like manner the pressure at C is 23.7 lb. absolute, and the weight per cu.ft. is 0.058 lb. At D the pressure is 17 lb. absolute and the weight 0.043 lb. per cu.ft. Therefore, the steam used at the crank-end stroke is:

$$(12.6 \times 0.058) - (0.91 \times 0.043) = 0.6917\ lb.$$



INDICATED HORSEPOWER	H P CYLINDER			L P CYLINDER			TOTAL I. HP
	HEAD	CRANK	TOTAL	HEAD	CRANK	TOTAL	
DOTTED CARDS	57.0	57.0	114.0	54.4	40.6	95.0	209.0
FULL LINE CARDS	57.5	51.4	108.9	49.9	51.4	101.3	210.2

Fig. 10

The total steam per revolution

$$0.8195 + 0.6917 = 1.5112\ lb.$$

Dry steam per hour equals

$$1.5112\ lb. \times 60\ r.p.m. \times 60\ min. = 5440\ lb.$$

The total indicated horsepower before setting the valves (diagrams Figs. 1 and 2) were 209. The dry steam per indicated horsepower per hour equals

$$5140 \div 209 = 26.03\ lb.$$

In the same way the dry-steam consumption after setting the valves was calculated to be 3688 lb. per hr., the indicated horsepower 210, and the dry steam per indicated horsepower 17.55 lb. At the plant in question 8.5 lb. of water were evaporated per pound of coal. The compressor runs for about 10 hr. per day for 300 days per year. The steam saved per hour is

$$5140 - 3688 = 1752\ lb.$$

and

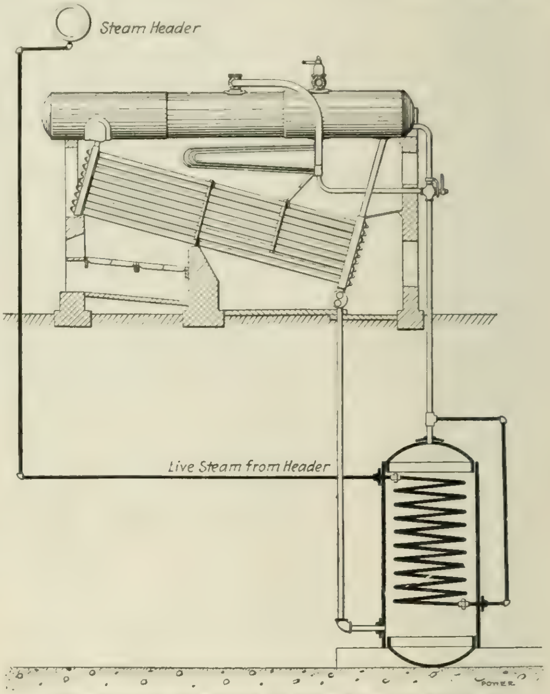
$$1752 \div 8.5 = 206\ lb.\ of\ coal\ per\ hr.$$

In other words, during a day of ten hours about a ton of coal was saved as a result of properly setting the valves on this compressor.

⁂

Quick Firing of Standby Boilers

A novel method of quick firing for boilers is described in the *Electrical World* for Dec. 6, with reference to the Ashley Street steam plant of the Union Electric Light & Power Co., of St. Louis. This company purchases electricity from the Mississippi River Power Co., at Keokuk, Iowa, to supply part of its system, but to guard against interruptions, should the hydro-electric power fail, the steam station is operated in such a manner as to be able to take over the entire load in a few minutes in an emergency.



Method of Keeping Water Hot in Boiler

This state of readiness is accomplished by keeping the 20 extra boilers full of water at 212 deg. and with fuel ready to ignite on the grates. The grate is first covered with a high-grade nut coal to a depth of about 7 in. and three rows of oily rags are then placed in cross trenches. Another row of rags extends down the middle to carry along the flame to all parts of the grate. On top of these rows of rags is laid kindling wood soaked in kerosene, while a few gallons of fuel oil are sprinkled over the entire bed of coal. This produces a hot fire very quickly and the best time made thus far in getting a boiler on the line, starting from zero-gage pressure, has been 16 min. This is a much shorter time than is required to get a boiler up to pressure from a banked fire.

The method of keeping water hot in the emergency boiler is shown in the illustration. The common blowoff header connecting the boilers in service was connected to the lower part of one of the two blowoff tanks in the basement. This header serves to bring the cool water from the lowest part of each boiler. In the tank is installed a coil through which the waste steam from one of the large steam headers is caused to flow, thus serving also to drain the header. The steam heats the water in the tank, sets up a circulation and delivers hot water to the steam drum of each boiler. The water is thus kept at practically the boiling point at a coal expenditure of only 12.5 lb. of coal per boiler per day as compared with 3100 lb. with banked fires.

⁂ ⁂

Air-Compressor Testing

By W. C. Lancaster

SYNOPSIS—Compressor efficiencies, data from test of a motor-driven two-stage compressor and the computations necessary to obtain the results.

⁂

Competition among air-compressor builders has been so keen in recent years that the would-be purchaser is often perplexed by the mass of data and technical figures presented by the manufacturer. Confusion lies chiefly in the question of efficiency. The mere statement that an air compressor has an efficiency of so many per cent. is not sufficiently definite. To be clear, the kind of efficiency that is meant must be stated since there are several different kinds all applicable to air compressors.

"Volumetric efficiency," or "delivery efficiency" as it is sometimes called, is the ratio of the volume of free air at intake temperature, actually delivered by the compressor per unit of time, to the displacement volume of the low-pressure cylinder in that time.

"Mechanical efficiency" represents only the loss due to the friction of the machine and heating of the air and jacket water. It may or may not include the belt or gear loss, if either of these drives is used, or it may include the friction loss of the steam engine if the compressor is directly connected to one.

"Compression efficiency" is a term sometimes used to express how close the actual compression line of a compressor comes to the isothermal line. If the isothermal line is drawn on the indicator card from the beginning of the stroke to the theoretical delivery line, the compression efficiency is the area under the isothermal and theoretical delivery lines divided by the actual area of the card.

"Electrical efficiency," of course, has nothing to do with the air compressor itself, but applies to the losses in the electric motor if used to drive the compressor.

All these various efficiencies are of much interest to the mechanical engineers who design air compressors and to the manufacturers who build them, but to the man who pays the bills for coal or electricity to run his plant they are usually only confusing. What he is really interested in is the number of cubic feet of air per minute actually delivered by his compressor per horsepower input. This represents the true economy of the compressor. It can be stated somewhat differently, as, for instance, "the kilowatt-hours input per 1000 cu.ft. of free air delivered" or "the cubic feet of air per pound of steam," or "the kilowatt input per 100 cu.ft. of free air per min. delivered." But all these are merely different ways of stating the relation between the amount of air actually compressed and pumped out by the compressor and the energy required to accomplish it. This is what the air-compressor operator really wants to know about a compressor before he makes the purchase, as upon this relation depends the amount of money he will have to pay out year after year for power to operate it.

After a compressor has been installed it is therefore desirable to run a test to determine exactly what the economy of the compressor is, both as a check on the manufacturers' guarantee and for the information of the owner.

A method of making such a test that has been found satisfactory by the writer will first be described, and then as an illustration an actual test will be worked out in detail. So much has already appeared in the technical press on the subject of steam-driven compressors that this article will be confined to those driven by electricity.

The two most important measurements to be made are:

a. The number of cubic feet of free air actually delivered by the air compressor.

b. The power input into the motor that drives the compressor.

Other measurements that will serve as a check on the above and give additional information about the compressor are:

c. (1) Indicator cards, (2) intercooler air pressure, (3) intercooler air temperature, entering and leaving, (4) intercooler water temperature, entering and leaving, (5) high- and low-pressure jacket-water temperature, entering and leaving, (6) amount of cooling water used in each cylinder jacket and intercooler.

Taking up these measurements in the order named, it has been found that the quantity of air flowing through an orifice varies directly as the area of the orifice and the absolute pressure and inversely as the square root of the absolute temperature. For pressures in the reservoir greater than twice the atmospheric pressure this relation is expressed mathematically in Fliegner's formula as follows:

$$G = 0.53\,F\,\frac{P}{\sqrt{T}} \qquad (1)$$

where

G = Flow of air in pounds per second;
F = Total area of all the orifices in square inches;
P = Absolute pressure in pounds per square inch in the orifice chamber;

T = Absolute temperature Fahrenheit of the compressed air in the orifice chamber.

For large air compressors a number of orifices are required. The orifices should be near the compressor and a pipe of large diameter and as straight as possible used to connect the discharge opening to the orifice manifold. The orifices are accurately ground in hardened-steel plates of from $\frac{3}{8}$ to $\frac{1}{2}$ in. thickness with the inside edges of the orifices rounded to a radius of $\frac{1}{16}$ in. less than the thickness of the plate, leaving $\frac{1}{16}$ in. of the hole straight. The shape of these orifices is illustrated in Fig. 1 and the method of assembling them with the valves and manifold is shown in Fig. 2. These plates with different sizes of orifices are placed in the manifold and the valves opened and closed until just the right orifices are found which will hold the pressure at whatever value it is desired to make the test.

A thermometer is inserted in the thermometer well provided in the orifice manifold and a pressure gage connected. The compressor is run until all parts are heated up and then readings are taken at short and regular intervals until the pressures and temperatures become constant. The amount of air discharged can then be figured by the use of equation (1). The writer believes that this method can be relied upon to give results accurate within about 2 per cent.

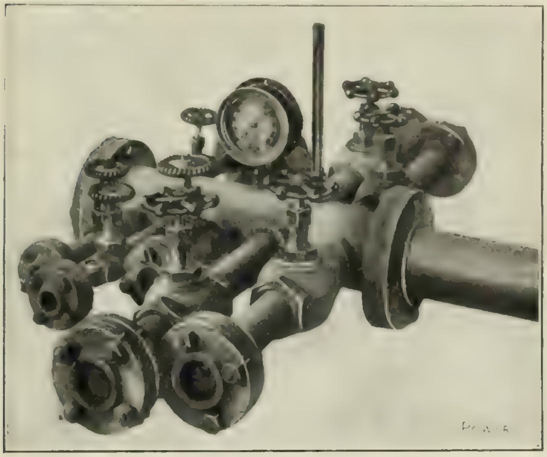


FIG. 2. ORIFICE MANIFOLD

The power input to the motor is obtained by inserting suitable electrical-measuring instruments into the motor circuit. If the motor is a direct-current machine, an indicating voltmeter and ammeter will be required. It will usually be found that two ammeters will be needed, one to read the current at full load and the other for the current when the compressor is "on a vacuum, as in this case the current is so small that the ammeter large enough to show the current at full load would read too low on the scale for accuracy. The power input is the product of the current and voltage. Several successive readings should be taken at the same time that the readings of the pressure gage and thermometer on the orifice manifold are read, and these readings averaged.

For a three-phase motor, either a three-phase wattmeter or two single-phase wattmeters can be used. If the latter, the power is the algebraic sum of the wattmeter readings. In either case, it may be necessary on account of large currents or high voltage to insert either current or voltage transformers, or both, between the motor circuit and the instrument. If this is done the meter readings must be multiplied by the ratio of the transformer, or by the product of the two ratios if both current and potential transformers are used.

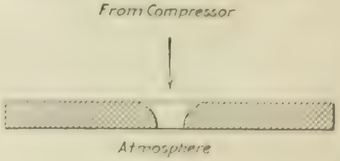


FIG. 1 - ORIFICE

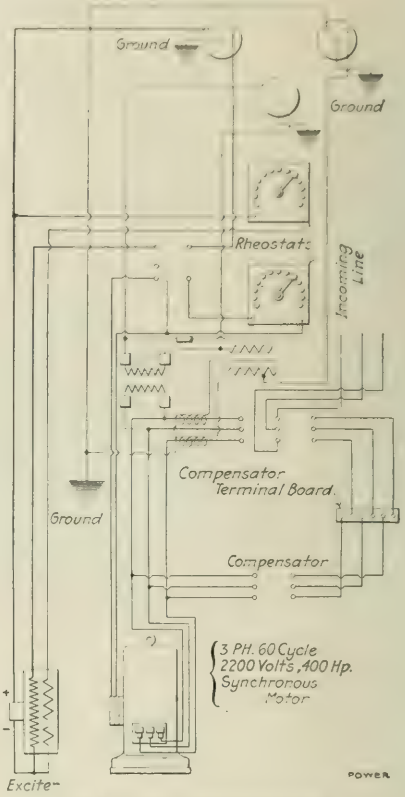


FIG. 3 - MOTOR WIRING DIAGRAM

For two-phase circuits, two wattmeters are used, the power being the arithmetical sum of the wattmeter readings multiplied by the transformer ratios.

Indicator diagrams should be taken on every test and if possible four indicators should be used so as to obtain simultaneous cards from each end of each cylinder. They are useful to show whether the valves were properly set during the test, and also to give the compression and mechanical efficiencies.

The method of figuring the compression efficiency has already been described. The overall mechanical efficiency is the ratio of the indicated horsepower, obtained in the usual way from the indicator diagrams, to the horsepower input into the motor. If it is desired to obtain the mechanical efficiency of the compressor only, it can be done quite accurately in the case of direct-connected compressors by making due allowance for losses in the motor from the motor builder's efficiency curve, but for belt-driven compressors it is difficult to separate the belt loss from the friction losses of the machine.

Readings *c*, from 2 to 6 inclusive, should all be taken, as they show the performance of the intercooler and cylinder jackets. The amount of cooling water required is an important item in the operating expense of an air-compressor plant. While usually small compared with the cost of power to drive the compressors, it is, nevertheless, quite appreciable, whether the water be purchased from city mains or pumped from a near-by source of supply, and should always be carefully reckoned in considering the economy of an air compressor.

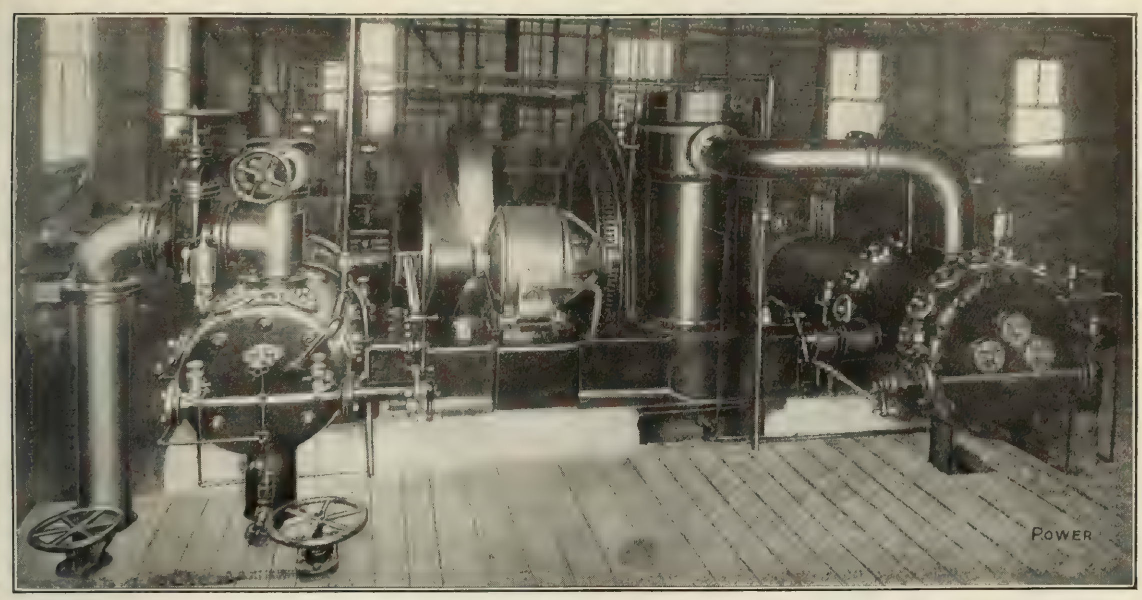


FIG. 4. MOTOR-DRIVEN TWO-STAGE AIR COMPRESSOR, 2100 CU.FT.

TEST OF MOTOR-DRIVEN AIR COMPRESSOR

The test run that will be recorded and then worked out as an example of the method described was made on a 26x15½x18-in. Sullivan two-stage compressor direct connected to a 400-hp., three-phase, 60-cycle, synchronous motor mounted on the crankshaft. The voltage is 2200 in the stationary armature and the revolving field is excited by current from a small generator belted to the flywheel. A wiring diagram of the motor is given in Fig. 3. There are two Corliss inlet valves on each cylinder, moved by eccentrics on the crankshaft. The air is discharged through poppet valves. There is an unloading valve on the inlet of the low-pressure cylinder, operated by air piped from the receiver and so adjusted that it will operate within a range of pressure of 5 lb. This valve is either fully open or tightly closed, so that the compressor is operating either at full load or at no load.

This air compressor is one of a number installed in the compressor plants for the construction of the tunnel under Mount Royal, Montreal, now being built for the Canadian Northern Ry. A view of the machine as it is installed is given in Fig. 4.

CALCULATIONS

With a low-pressure cylinder of 26x18 in., the displacement per revolution is 19,021.14 cu.in. The speed in revolutions per minute is

$$(157{,}665 - 153{,}032) \div 25 = 185.3$$

The displacement equals

$$\frac{19{,}021.14 \times 185.3}{1728} = 2039.7 \textit{ cu.ft. per min.}$$

The area of the orifices is as follows:

One ⅝-in. orifice, sq.in.	0.3068
Three ½-in. orifices, sq in.	0.58905
One ¼-in. orifice, sq.in.	0.04908
Total, sq.in.	0.94493

The absolute pressure of the atmosphere, with a barometer of 29.9395 in. equals

$$29.9395 \times 0.4908 = 14.694 \textit{ lb. per sq.in.}$$

Adding to this 103 lb., which from the log is the pressure at the orifice, gives 117.694 lb. per sq.in. abs. as the pressure in the orifice chamber.

The temperature in the orifice chamber from the log is 227 deg. F. Adding 460 to find the absolute temperature gives 687, and the square root of 687 equals 26.216.

At the intake temperature of 59 deg. F. the weight of 1 cu.ft. of air is

$$W = \frac{1.325 \times B}{460 + t} = \frac{1.325 \times 29.9395}{460 + 59} = 0.07643 \textit{ lb.}$$

From Fliegner's formula

$$G = 0.53\, F \frac{P}{\sqrt{T}}$$

$$G = \frac{0.53 \times 0.94493 \times 117.694}{26.216} = 2.248 \textit{ lb. per sec.}$$

$$\frac{2.248 \times 60}{0.07643} = 1764.75 \textit{ cu.ft. per min. of free air at 59 deg. F.}$$

The volumetric or delivery efficiency equals

$$1764.75 \div 2039.7 = 86.5 \textit{ per cent.}$$

A method often used to figure the volumetric efficiency is to divide the length of the line *ab*, Fig. 5, by the length of the atmospheric line *ac*. This method, however, gives too high a value as it does not allow for slippage at the discharge valves and leakage past the piston. It might more properly be called "intake efficiency" when figured this way.

For the test considered, the volumetric efficiency figured in this manner works out as follows: For the crank end *ab* ÷ *ac* = 96.9 per cent., and for the head end, 98.8 per cent. The average of these is 97.85 per cent., which, when compared with the value 86.5 per cent. found above, illustrates clearly what a widely different result may be obtained by the indicator-diagram method.

At 111 lb. per sq.in. terminal pressure, the average of the last three readings, the power input was 316 kw. Reducing this to 100 lb. per sq.in. terminal pressure, on the assumption that the power is proportional to that required for adiabatic compression (which is a sufficiently close approximation),

$$316 \times \frac{15.3}{16.15} = 299.4\ kw. = 401.8\ hp.$$

Kw input per 100 cu ft per min., free air at 100-lb. gage output	=16.96
Hp input per 100 cu ft. per min., free air at 100-lb gage output	=22.75
Cu ft. per min., free air output at 100 lb. gage, per kw-hr., input	= 4.395
kw-hr per 1000 cu.ft. free air	2.83
Cu ft. per min., free air output at 100 lb. gage, per kw-hr. input	=353.5
Power input at no load with the compressor operating at full speed, but with the intake cut off and, therefore, pumping no air, kw	38

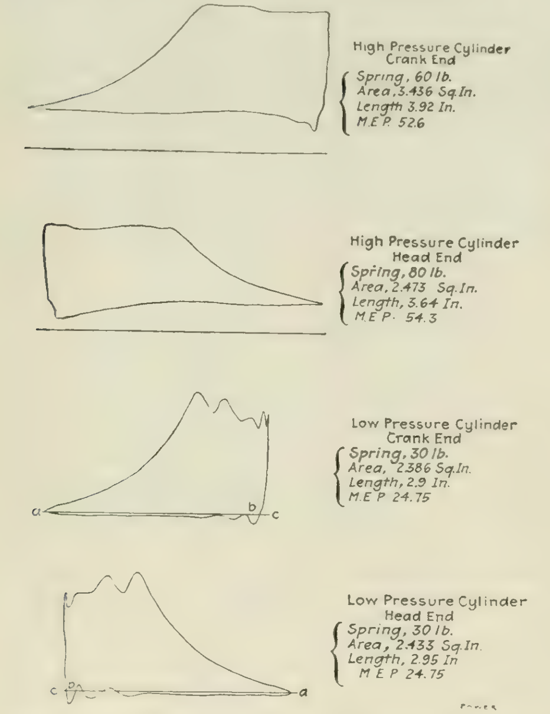


FIG. 5. TYPICAL INDICATOR DIAGRAMS FROM COMPRESSOR

Typical indicator diagrams, taken during the test, are shown in Fig. 5. The indicated horsepower of the low-pressure cylinder equals

$$\frac{24.75 \times 530.93 \times 1.5 \times 371}{33,000} = 221.55$$

The indicated horsepower of the high pressure cylinder equals

$$\frac{53.45 \times 188.69 \times 1.5 \times 371}{33,000} = 170.08$$

Adding gives 391.6 i.hp. The total input = 316 kw. = 423.6 hp. Then the mechanical efficiency equals

$$\frac{391.6}{423.6} = 92.5\ per\ cent.$$

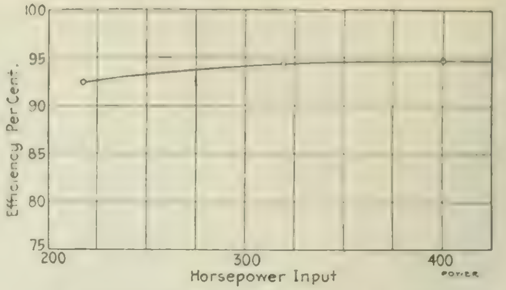


FIG. 6. EFFICIENCY CURVE OF 400-HP. SYNCHRONOUS MOTOR

From the efficiency curve of the motor, furnished by the motor manufacturer, Fig. 6, it will be noticed that the electrical or motor efficiency at 423.6 hp. input is 94.6 per cent.

Since the overall efficiency has been found to be 92.5 per cent., the mechanical efficiency of the compressor exclusive of the motor is

$$0.925 \div 0.946 = 0.977 = 97.7\ per\ cent.$$

SUMMARY OF TEST RESULTS

Hp. input per 100 cu.ft. per min. of free air at 100-lb. gage output	22.75
Cu.ft. per min., free air output at 100-lb. gage per hp. input	4.395
Kw.-hr. per 1000 cu.ft. free air	2.83
Power input at no load, kw.	38.00
Overall mechanical efficiency, including motor, per cent.	92.5
Mechanical efficiency exclusive of motor, per cent.	97.7
Volumetric or delivery efficiency, per cent.	86.5
Cooling water during test, cu.ft. water per 1000 cu.ft. air	1.00

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Interviewing a Grate Salesman

By R. O. RICHARDS

"Why do my grates deteriorate faster at the front than at the back end of a furnace?" the chief inquired in the course of conversation with the visiting grate salesman.

"Because," the salesman replied, tipping his hat to the back of his head, "in ordinary firing more pounds of coal per square foot of grate surface are consumed there, while, relative to the rate of combustion, less air—the grate-cooling factor—passes through the air spaces. The volume of air which passes through the body of the fire, immediately after a fresh charge of fuel is fed to the furnace, is insufficient for complete combustion, and the auxiliary supply admitted through the grating of the furnace doors, is so limited in volume that only the fuel immediately back of the doors is benefited. Consequently, the front part of the fire reaches incandescence sooner than any other part of the furnace, with the possible exception of narrow strips placed next to the heated side walls.

"Air admitted above the fuel is not a grate-cooling factor, and the air supplied through the ashpit doors is retarded somewhat from reaching the front quarter of the grates because of the sharp deflection in the direction of its flow.

It is not difficult to conceive that a strip of grate in the front of the furnace, varying in width from 1 to 2 ft. is subject to comparatively high temperatures, and therefore deteriorates more rapidly than the rest of the grate. For this reason I recommend either slightly closer air spaces in the rear grates, or more cooling surface, greater depth of bar, in the front grates.

"Although holding that the lack of sufficient cooling surface is the chief cause, I am of the opinion that an unequal and slovenly manner of firing is also a fruitful source of grate deterioration. When a hole is burnt in the body of the fuel most of the air will pass through this point of least resistance, and consequently the rest of the grate will suffer from the heat. Especially is this true with heavy fires, light steam demand and partly open damper.

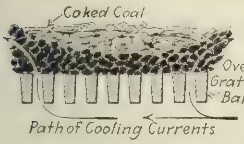

FIG. 1. AIR PATH THROUGH FUEL

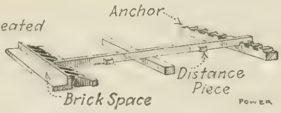

FIG. 2. CROSS-BAR GRATE SUPPORTS

"If the fireman, instead of leveling the fire, fills the hole with green coal, the draft will be almost checked there, and this green spot will soon suffer from excessive heat by the coking of the coal on top, and its ignition by convection near the grate. Fig. 1 makes this point clear."

"Now, tell me," said the chief, "why, when a grate-bar warps, it burns and breaks sooner than a bar that has not warped, but is otherwise not in as good condition. What is the reason?"

"That," replied the salesman, "occurs most frequently to a bar that has arched upward than to one that has sagged. One of the principal factors of grate economy is the maintenance of an even surface—one without irregularities in either the bars or the finger-pieces. In general, the bars wear evenly relative to one another, and, if they be so maintained, good service may be expected, though they may have sagged considerably at their mid length. But when they are disturbed and replaced without regard to their former evenness of surface, you may be sure that they will soon be destroyed.

"It is as important to number the bars of a grate when it is being removed as to mark the parts when disjoining any apparatus in the engine room. If this is not done the grate surface will be uneven (Fig. 3) when replaced and from the moment the furnace is lighted, the fire on the one hand, and the fireman's slice-bar on the other, will contend which shall level the most projections in the shortest time."

"Which is the better, a thick bar or a thin one?" asked the chief, as he stabbed a blotter with his new fountain pen. "Many engineers infer that since less grate surface is in contact with the fire, a thin bar is preferable, but reliable tests have proved that the grate receives heat as much from radiation through the interstices, as from direct contact with the burning fuel. Consequently, there being less material and only the same amounts of cooling surface, a thin bar must become many degrees hotter than a thick one, and, not having the rigidity of the latter, will soon bend sidewise, so that two or more come in contact, causing wasteful enlargement of the air space on one side and serious diminution of the cooling surface on the other.

"Other considerations favorable to the use of thick grate bars are that they better sustain a layer of protective ash, and maintain the line of fire farther removed from their own surface.

"What factors govern the depth of a bar," was the chief's next inquiry, to which the salesman replied without hesitation:

"The length of the bar, the amount of fuel burned per square foot per hour, and the width of the air spaces. The latter consideration is rarely taken into account in grate design, but is a factor that materially influences the temperature of the grate. Grates between which are wide air spaces are subject to more radiation of heat than those having narrow air spaces between them and they should show more cooling surface or a greater depth of metal in the bar.

"In this country cast-iron grates have little or no competition; but in Europe steel and wrought-iron grates are used in plants that consider length of service and not initial cost, as the true measure of grate economy. The most common form is a series of straight bars extending unbroken from the front arches to the bridge-wall, and supported at the center by a girder. The bars are generally forged 4 in. deep, and about three-quarters of an inch thick. They are tightly packed latitudinally by distance pieces, but are free to expand lengthwise, being anchored near the bridge-wall. (See Fig. 2.) Their chief advantage is, that warped bars may be straightened and impaired bars welded and reforged. They have a smooth surface and the fires are more easily barred. The fire end of the slice bar is forced so that the lower lip slides between two bars and cuts all clinkers that may adhere to the sides." (See Fig. 4.)

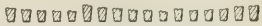

FIG. 3. UNEVEN GRATE

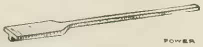

FIG. 4. SLICE BAR

Just then the whistle blew for dinner and the salesman, losing all interest in talking grates, caught a trolley headed for the hotel dining room.

Pumping against 2250-Lb. Pressure*

Water used by the rack-and-cog-type locomotives that haul cars to the top of Mount Washington, N. H., take water from a pipe along the track instead of carrying it in a tender.

The water is pumped to the top of the mountain by duplex pumps near the base. The pressure pumped against is 2250 lb. The steam cylinders of the pump are 16 in. in diameter and the water cylinders are 3 in. in diameter. The stroke is 18 in. The discharge pipe is 2 in. in diameter and ½ in. thick for half its length and ⅜ in. for the remainder. The intake pressure is 80 lb., furnished by a dam in the Ammonoosuc River. The pumps are located 2540 ft. above sea level and pump water to the summit at an elevation of 6280 ft.

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*Excerpts from "Engineering Record."

Electrical Department

Centralized Control System for Panama Locks

The operation of the Panama Canal locks, terminals and auxiliary equipment utilizes electrical energy throughout, with the present exception of the Panama Railroad, the electrification of which is under contemplation.

Generation and Distribution

Power for the operation of the locks, towing locomotives, lights, etc., is to be furnished by a 7500-kv.-a., 2200-volt hydro-electric plant at the Gatun Dam; the steam plant at Miraflores, which supplied power for construction work, will serve as an emergency plant. These will supply, through 2200/44,000-volt transformers, two parallel, three-phase, 44,000-volt transmission lines extending across the Isthmus from Balboa to Cristobal, where substations step down to 2200 volts. The electricity at these points is used for operating the coal-handling plants, the machine shops, dry docks and for general lighting.

Thirty-six 2200/240-volt substations supply the three sets of locks, Gatun, Pedro Miguel and Miraflores, with power and light. In addition there are three 2200/220/110-volt transformer stations for the control boards at the locks.

The following list gives an idea of the number and sizes of motors to be controlled in operating the lock machinery:

Machines and Operation	Motors, Each Machine and Hp	Number of Motors Gatun	Pedro Miguel	Miraflores	Total Hp
Miter gate, moving, each leaf	1-25	40	24	28	2,300
Miter gate, miter forcing	1-7	20	12	14	322
Fender chain, main pump	1-70	16	16	16	3,360
Fender chain, operating valve.....	1-½	16	16	16	24
Rising stem gate valve...........	1-40	56	24	36	4,640
Cylindrical valve.................	1-7	60	20	40	840
Guard valve	1-25	6	6	6	450
Auxiliary culvert valve...........	1-7	4	4	4	84
Total		218	122	160	12,020

This does not include a number of smaller motors, such as those for the spillway gates, the hand rails on the miter gates and the sump pumps. The motors are started through contactor panels located near them, but controlled from the central control house. The smaller motors, including those for cylindrical valves, auxiliary culvert valves and miter forcing, are started by being thrown directly on the line. Two double-pole contactors are used, one for forward and one for reverse. In the case of larger motors for miter-gate moving, rising-stem valves and guard valves, a starting point with resistance in two legs of the three-phase circuit is provided.

In all cases the contactors are operated from the control boards, to be described later, by three wires, one for forward, one for reverse and a common return. In the case of panels having a starting point, the period during which the motor remains on the resistance is automatically controlled by a dashpot, so that the starting operation at the control house is the same, simply energizing a forward or reverse wire as the case may be.

Location and Operation of Lock Machinery

From an operating standpoint the machinery was placed below the coping of the lock walls, thus affording a clear space for maneuvering ships and protecting the apparatus from the weather without erecting numerous houses.

The miter gates consist of two massive leaves pivoted on the lock walls and operating independently of each other. A pair of gates is located where each change of level occurs and divides the locks into 1000-ft. chambers. In addition at the lake and ocean ends are duplicate pairs serving as guard gates. To handle the vessels of various sizes with the minimum use of water, similar miter gates are placed in intermediate positions dividing the 1000-ft. locks into two compartments.

On the top of all miter gates a foot walk with hand rails is provided. When the gates are open and in the recesses in the lock walls, these hand rails would interfere with the passing of the towing locomotives; therefore, they are raised and lowered by a motor under the foot walk, controlled from the lock wall by a foot push controller. If the hand rails happen to be left up and the gates are opened by the operator in the control house, they will be lowered automatically.

Chain fenders are stretched across the canal in front of all miter gates, which can be exposed to the upper-lock level and also in front of the guard gates at the lower end. These are maintained taut when the gates behind are closed, and are lowered when the gates are opened for the passage of a ship. The chains are raised and lowered by a method similar to that followed in hydraulic elevators, with the additional feature that if a ship approaches the gates at a dangerous speed and rams into the chain, the latter is paid out in such a way as to gradually stop the ship before it reaches the gates.

The filling and emptying of the locks is accomplished by three culverts, one in the middle wall and one in each side wall, the flow of water being controlled by rising-stem valves. These are located in the culverts at points opposite each end of each lock so that the culvert can be shut off at any desired point for filling a lock with water from above, or upstream, or for emptying it by allowing it to flow out and down to the next lock. Lateral culverts conduct the water from the main culverts, under the lock chambers, and up through openings in the lock floors.

The rising-stem valves are installed in pairs, and each pair is in duplicate; also each culvert is divided into two parallel halves by a vertical wall, which reduces the size of each valve and makes it more easily operated. One pair of duplicates is left open as an emergency or reverse pair. The culvert in the middle wall must serve the locks on both sides and to control this feature cylindrical valves are placed in the lateral culverts that branch out on each side.

Centralized Control and Indicating System

As the flight of locks at Gatun, for instance, extends over approximately 6200 ft., and, the principal operating machines are distributed over a distance of about 1000 ft., it will be seen that a centralized electrical control is essential.

The control boards are installed in control houses (see Fig. 3), located on the middle walls at points which afford the best view of the locks, although this view is not depended on to know the position of the gates or other apparatus, as there are indicators on the control boards. These boards are operating miniatures of the locks themselves, and are arranged with indicating devices which show the position of valves, lock gates, chains and water levels, and with the exception of such machinery as needs only an open or closed indication, the indications will be synchronous with the movement of the lock machinery.

The control boards (Fig. 1), are of flat-top benchboard type, 32 in. high by 54 in. wide, built in sections, with total lengths as follows:

Gatun	64 ft.
Pedro Miguel	36 ft.
Miraflores	52 ft.

The side and center walls of the locks are represented by cast-iron plates and the water in the locks by blue Vermont marble slabs.

The control-switch handles are mounted above the surface of the board and operate through an angle of 90 deg. They are provided with nameplates for the "open" and "closed" positions. The space immediately below the flat top of the control board is occupied by the contact fingers of the control switches, mounted on the operating shaft, synchronous receivers and their cable connections. The receivers, transmitters and lamps are operated at 110 volts, while the control circuits are at 220 volts, both using 25-cycle alternating current.

The synchronous indicators, which were developed especially for this undertaking, consist of a transmitter located and operated by the machine in the lock wall, and a receiver operating an indicator at the control board. Both transmitter and receiver have a stationary and a rotating part. The stators have three-phase windings with leads brought from the transmitter and connected to three corresponding equidistant points of the receiver. These stator windings are not connected to a source of power, but are energized by induction from the rotors. The latter are bipolar and are connected in multiple and energized from a 110-volt, 25-cycle, single-phase source.

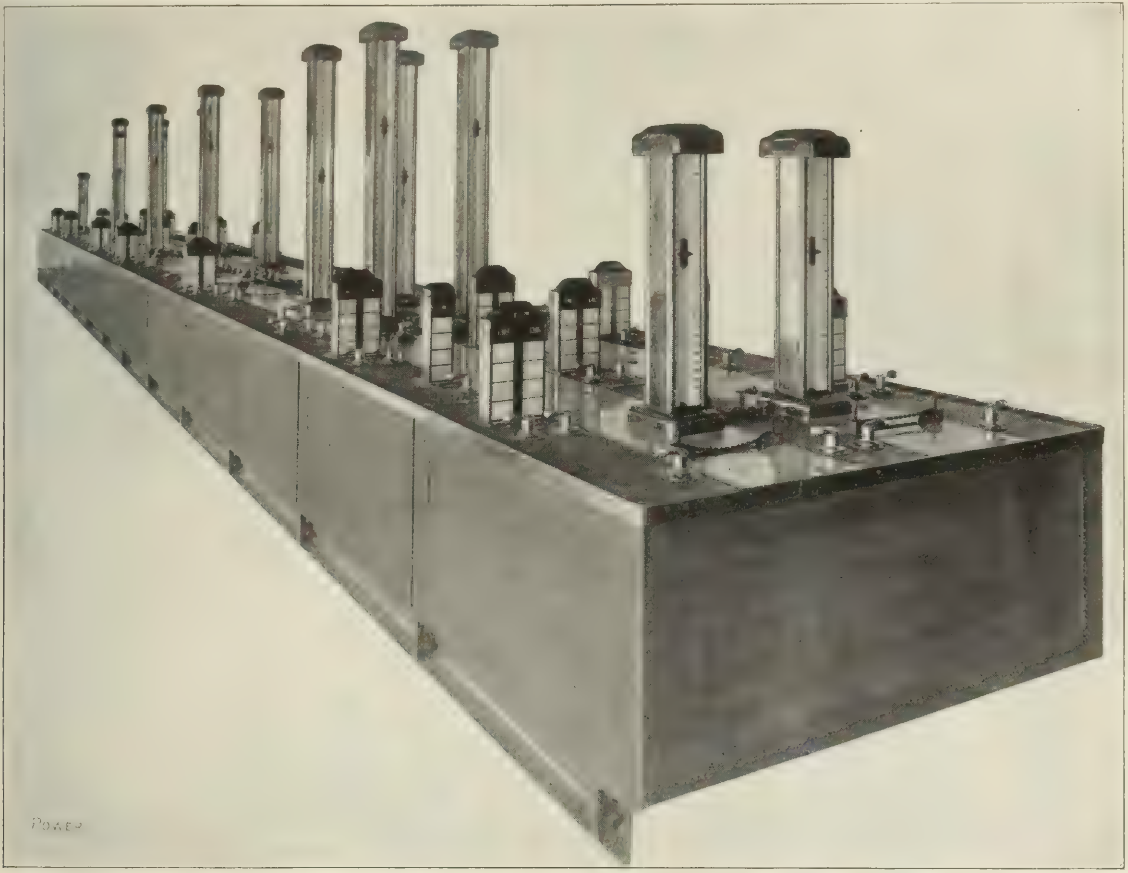


FIG. 1. CONTROL BOARD FOR MIRAFLORES LOCKS

Movement of the lock machinery, with the connected transmitter rotor, induces voltage in the transmitter stator coils. This induced current is transmitted to the receiver-stator coils and duplicates in them. The rotor of the receiver, being energized by the external source in the same direction as that of the transmitter, is reacted upon by the polarized receiver stator until the magnetic axes coincide and the rotors of both transmitter and receiver are in the same relative position. Any difference in the position of the transmitter and receiver rotor causes a difference of potential between the stator windings with a consequent flow of current and resultant torque, which again moves the receiver rotor to the same relative position as that of the transmitter rotor. The receiver rotor follows closely and smoothly the movement of the transmitter rotor, and consequently imparts to the position indicator a movement identical with the movement of the lock machine, although on a scale reduced to the requirements of the control board.

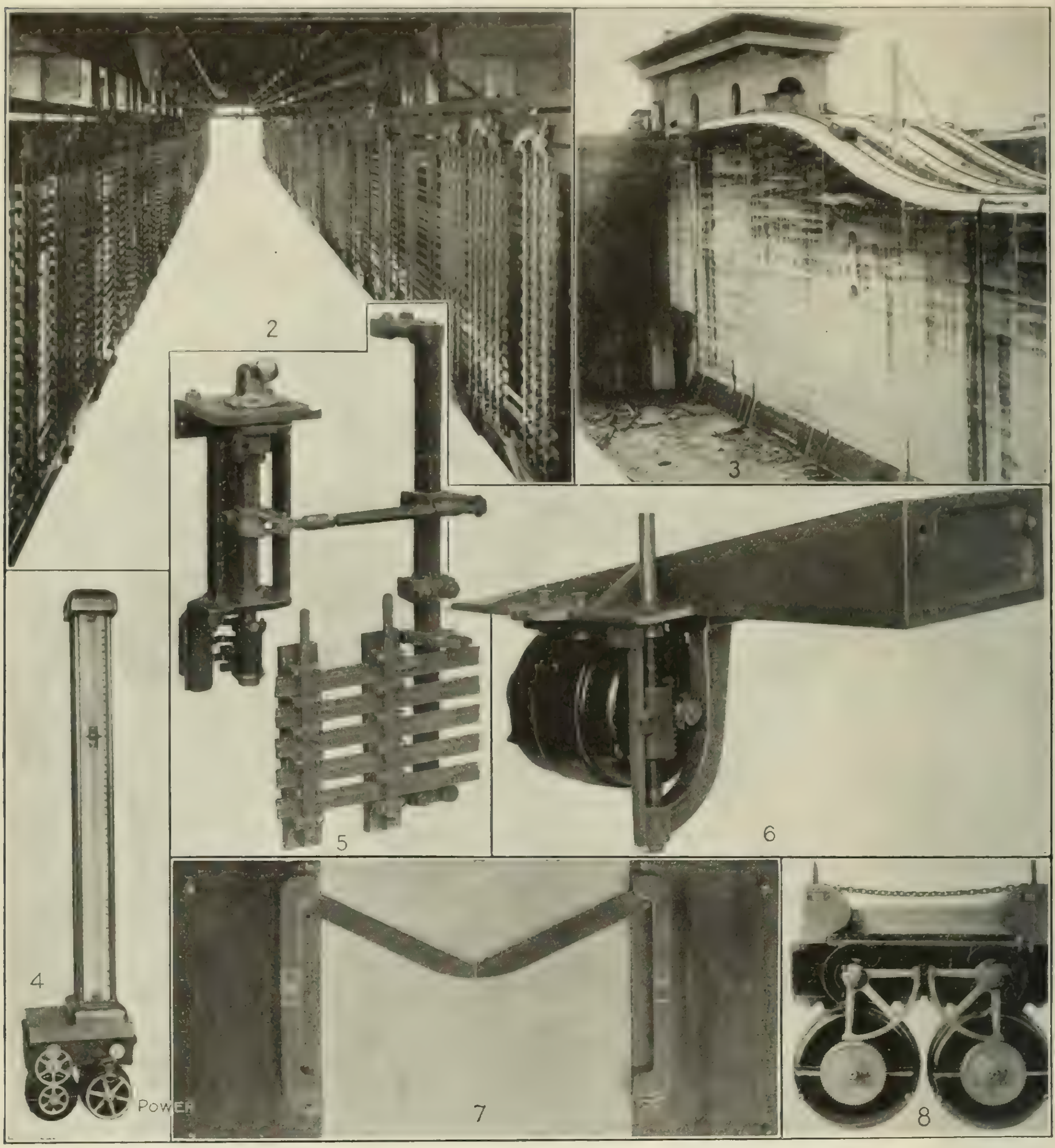


Fig. 2. Interlocking System under Control Board. Fig. 3. Control House on Center Wall of Upper Locks. Fig. 4. Water-Level Indicator. Fig. 5. Control Switch and Interlock Mechanism. Fig. 6. Miter-Gate Transmitter. Fig. 7. Miter-Gate Index. Fig. 8. Chain-Fender Index

In the case of the miter gates, the vertical operating shaft is connected to a shaft which operates the transmitter machine. The latter shaft is threaded and carries a nut on which is mounted a rack. The rack engages a gear on the rotor shaft (Fig. 6), and this turns the rotor as the gates operate. The miter-gate indicator (Fig. 7) comprises a pair of aluminum leaves, shaped to correspond to the plan view of the top of the gate, which travels horizontally just above the top of the board, the hinge ends being connected to shafts extending down through the surface of the board where they are geared to the receivers by bevel gears.

For the chain fender, the position-indicator transmitter is driven by the shaft which operates the limit switch that controls the stroke of the piston. The indication on the board is given by a small aluminum chain (Fig. 8) which, like the large chain, is raised and lowered, each end operating independently.

As the rising-stem valves occur in pairs, their position-indicator machines occur in pairs also. The transmitter rotor is driven by a shaft and gearing similar to that described for the miter gates. Each indicator is similar to a small elevator, a car being used to indicate the position of the valve gate. Both front and back of the shaft are fitted with opal glass marked with black lines for the ¼, ½ and ¾ positions. A small aluminum cage moves up and down in each compartment.

WATER-LEVEL INDICATORS

The specifications covering the water-level indication required an accuracy of $^{1}/_{20}$ of a foot in actual water level. In the transmitters and receivers for the machines described previously, the rotors turn less than 180 deg. with an inherent lag of 1½ per cent. between the transmitter and receiver rotors in this distance, which obviously prevents this arrangement from being employed to give the water-level indication.

It was found that if the rotors were revolved ten complete revolutions, the required accuracy could be obtained; but since this makes it possible for the rotors to be in synchronism every 180 deg., or in twenty different positions for the entire travel, the indicators would not indicate correctly if for some reason the transmitter rotors were turned more than one-half revolution with the power off. Therefore, the required accuracy was obtained by two sets of transmitters and receivers, one set connected to a fine index in which the rotors make ten complete revolutions and the other set connected to a coarse index operation, less than 180 deg.

The fine index is a hollow cylinder carrying a pointer, the length of the cylinder being such that when an aluminum ball representing the coarse index, which can be depended upon for coarse indication, is within the limits of the cylinder, the reading of the fine index is correct within the limits specified. The scales are illuminated by lamps in both base and top caps of the indicator.

For water-level indication, walls 36 in. square in the lock walls with communication to the lock by a small opening at the bottom of the wall to dampen surges contain a welded-steel box float, 30 in. square by 9 in. deep. A nonslipping phosphor-bronze belt transmits the movement of the float to a sheave fitted with pins on the transmitter mechanism, the pins registering with holes punched in the belt.

MECHANICAL INTERLOCKING SYSTEM

To make it necessary for the operator to maneuver the control-switch handles always in a certain order, corresponding to a predetermined sequence of operation of the lock machinery, and to prevent the operator in control of one channel from interfering with the machinery under the jurisdiction of the operator controlling the other channel, these control switches are provided with interlocks, as shown in Figs. 2 and 5. These are in two vertical racks under each edge of the board and some distance below, so that they may be easily inspected and oiled.

Vertical shafts operated by connecting rods from the control-switch shafts extend downward past the electrical parts for the operation of the interlocks. The interlock system is essentially a bell-crank mechanism, connecting the shaft of the control switch through a movable horizontal bar to a vertical operating shaft, which can or cannot move, according to the relative positions of the interlocking bars and dogs.

Interlocks prevent the chain fender from being lowered until adjacent miter gates have been opened, and also prevent the gates being opened until the chain is in the raised position. After the miter gates are closed, a miter forcing machine is operated by a control handle and locks the ends of the gates. This machine cannot be operated until the gates are closed.

Also the rising-stem valves of the side wall, next above or below a miter gate, must be closed while the miter forcing machine is open. As the miter forcing machine cannot be closed until the gates are closed, this means that the valves either above or below the gate must remain closed until the gate itself is closed, thus preventing the operator from creating a current of water around the gates while they are open, or being moved in opening or closing.

Either pair of rising-stem valves may be opened first, the interlock becoming effective when the first valve of the second pair of duplicates is opened. The cylindrical valves are interlocked so that if those on one side are opened, the ones on the other side will lock the opposite ten. This prevents careless cross filling between locks, which operation might be combined with the regular method and produce flooding. However, there may be times when it is desirable to employ cross filling to economize in the use of water from Gatun Lake in the dry season. For this reason this interlock is made removable by the use of a Yale lock, the key being retained by the chief operator.

In most cases the locks are divided into two unequal parts by the intermediate miter gates. This makes it necessary to divide the ten cylindrical valves into two groups of seven and three, respectively, for the long and short lengths. A selecting lever is provided for these interlocks and may be set as indicated by a nameplate on the lever to "three," "seven" or "ten," respectively; whereupon the corresponding valves are subject to that interlock, and the others of the group of ten are locked closed if three or seven only are used.

To withstand the humid atmosphere of the Isthmus, every insulated part, such as solenoid, relay, circuit-breaker and other coils, was impregnated with nonhygroscopic compounds. All small parts were made either of brass, copper, Monel metal, bronze or of sherardized iron or steel. Mica and treated asbestos lumber were used largely in place of fiber or wood.

Nearly two thousand special drawings were required in the fabrication, and in the construction of the boards there was employed more than 2½ miles of interlocking rod, about six million feet of control leads, 732 indicator motors, and 464 control switches.

All the lock-machinery motors, control, panels, centralized control boards, power-station generating apparatus, switchboards, transmission-line substation equipment for the wharf terminal cranes, etc., were manufactured by the General Electric Co.

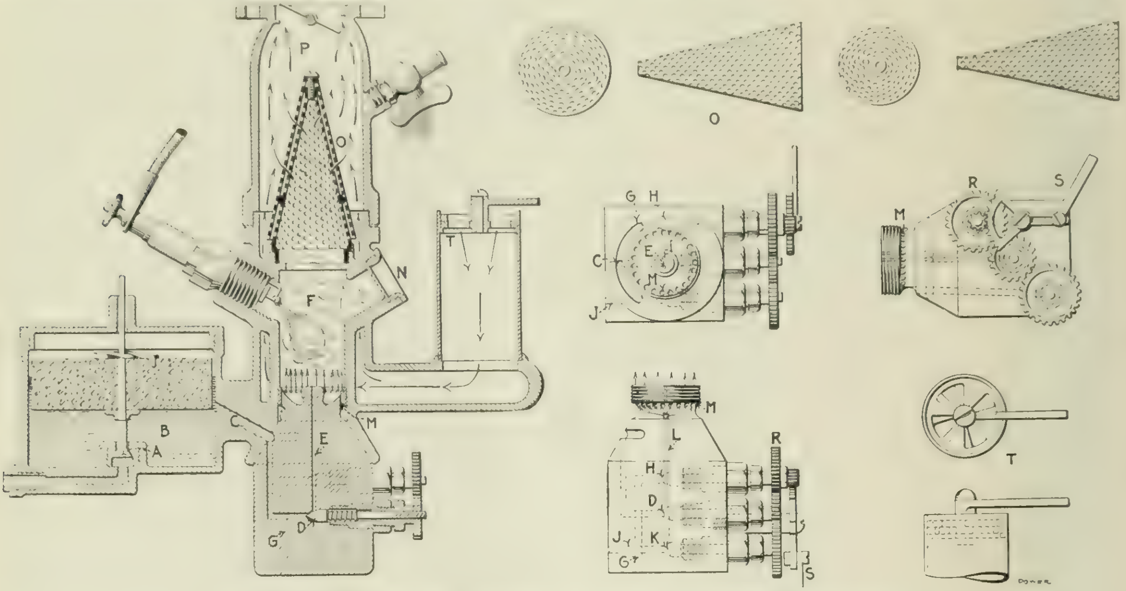
Gas Power Department

A Unique Kerosene Carburetor

By J. A. Lucas

It is generally conceded by those who have acquired experience in the kerosene-carburetor field that the application of heat at some period of the travel of the fuel from the tank to the motor is necessary. The application of heat, however, must be carried out with extreme delicacy for if there is insufficient heat the process of vaporization is but slightly furthered, while if there is too much heat a chemical action known as "cracking" takes place, the kerosene splits up into its components, and the result is poor combustion, an odoriferous exhaust and an abundant deposit of carbon in the combustion chambers and other parts.

To those familiar with the more conventional lines of endeavor that have been followed in many attempts to solve the kerosene-carburetion problem the idea of applying heat by starting a fire, so to speak, in the mixing chamber of the carburetor itself, doubtless appears revolutionary. Yet it is by this very process that Alexander E. Porter, of 171 Broadway, New York, has succeeded in producing a kerosene vapor that differs widely from vapors formed by more familiar processes.



Sectional View and Details of Porter Kerosene Carburetor

Preliminary Experiments

Before describing the construction of the apparatus it might be well to mention some of the preliminary results of its peculiar action.

While the carburetor is in actual service it is operated in the usual way by the suction of the motor. The experimental carburetor employed on the bench to demonstrate the principles of operation, however, is worked by compressed air, the office of which is to atomize the kerosene as the initial step in the process. The atomized kerosene (without the application of heat) issues in a spray which will rapidly condense on the hand and drip off. The instant a flame is applied, however, under the proper conditions of mixture, the characteristics of the vapor are entirely changed, and it becomes a thick, white vapor, strongly resembling steam, and the most interesting thing about it is that it is decidedly difficult to condense. It floats in the air like smoke and disappears in the same gradual way.

The pure vapor, close to the discharge pipe, cannot be ignited with a naked flame. Further out, however, where there is an admixture of air, it can be ignited with a match, and burns with a reddish flame. It is notable, however, that the flame gives off no smoke and produces no deposit.

The same procedure in the case of the raw spray of kerosene results in the usual smoke and shower of small particles of black carbon in the air. The vapor is easily caught in a wide-mouthed bottle held over the discharge pipe of the carburetor, and, despite the coldness of the glass walls, remains visible in the bottle for 14 min. by the watch.

If a bottle of the white vapor is opened for a moment and a little air admitted, a match applied to the mouth will ignite the mixture, which will burn very rapidly and with a slight puff of flame, but without any deposit of carbon.

The conclusion naturally drawn from these demonstrations is that by this method it is possible to produce a kerosene vapor that is sufficiently stable to withstand condensation considerably longer than is necessary to get it into the cylinders of a cold engine and ignite it. Furthermore, it would appear that under normal conditions combustion should take place without smoke or odor and without leaving deposits in the cylinders.

Referring to the illustration, showing a section through the carburetor and various details, the kerosene enters through a float valve *A* into the chamber *B*, thence through the passage *C* to the needle valve *D* and passage *E* to the atomizing chamber *F*. Atomizing air is drawn in by suction through the passage *G*, past the needle valve *H* and up through *I*, where being directed against the jet of kerosene, breaks it up into a spray. Air is also drawn in through the passage *J* past the needle valve *K* and up through passage *L*, thence through the annular holes *M*, as indicated by the arrows, and into the atomizing chamber *F*.

The spark plug ignites a small portion of this atomized kerosene mixture which burns as a small ball of fire and may be seen through the mica window *N*. The screen *O* prevents any flame from extending to the upper part of the carburetor. A single screen was first tried, but this was found to heat up after a few minutes and ignite the vapor in the upper chamber. The double screen, however, prevents this.

Because of insufficient air in the chamber *F* only a very small portion of the kerosene burns and furnishes just enough heat to break up the remainder into the form of a dense white vapor as previously mentioned. The proportions of air and kerosene entering this chamber are controlled by opening the needle valves, *D, H* and *K*, which are connected through gearing *R* (maintaining a constant ratio), the movement being controlled by a lever *S*, which operates in unison with the throttle.

The auxiliary air for supplying the proper mixture to the engine cylinders enters through the sliding throttle *T*, and up into the mixing chamber *P* as indicated by the arrows.

The spark plug is operated from an independent spark coil with a switch on the dash, and after the carburetor has been in operation a few minutes the current may be turned off and the ball of fire will continue to burn in chamber *F* and the carburetor will work as usual for a long period.

The motor starts, when cold, on the kerosene, apparently as easily as on gasoline. There is this difference between gasoline and kerosene, however:

Judging from the running of the motor, the kerosene burns more slowly than gasoline, there being apparently more gradual expansion and less of the explosion effect. The correctness of this would seem to be borne out, in a measure at least, by the fact that the motor will throttle down to a lower speed than with gasoline and will "hang on" when climbing a grade on high gear in a way that is rather surprising. While the speed of combustion is quite sufficient for all ordinary purposes, when a motor is raced to an excessive speed the power falls off sooner than with gasoline.

No trouble has been experienced from deposits in the cylinders or on the spark plugs except when the flame in the carburetor has been momentarily extinguished and raw kerosene vapor has been drawn in.

The vapor at the point of combustion is too rich to burn rapidly, burning beyond the screen is impossible and a backfire from the motor would have a tendency to extinguish the flame momentarily. Hence, there is no danger from the flame.

Most of the road test work with this kerosene carburetor has been with a large and heavy six-cylinder car, which is notoriously wasteful in the matter of fuel consumption, and the manufacture of which has been discontinued. The motor is rated at 60 hp. Running on gasoline the best average that could be made was five miles to the gallon of fuel. On kerosene with this carburetor the average rose to 10.5 miles per gallon, and the motor showed an appreciable increase in power, especially on hills.

*

Estimating Cost of Power in Producer-Gas Plant

By G. A. Field

The following is a preliminary estimate of the costs of a 300-hp. gas engine and producer. The engine is assumed to be a three-cylinder, vertical type and the producer to be of the bituminous water-sealed type with superimposed vaporizer. The estimate includes the first cost of the engine and producer erected on foundations, together with all piping and gas-cleaning apparatus and coal-handling machinery, also the annual cost of operation.

It is understood that the factors and assumptions used will vary through a wide range, depending on the following:

1. The nature of the service required, whether to drive electric generators, air compressors, ordinary mill machinery, etc. In many of these cases it might be advisable to plot the load curve before deciding upon the size of the units.

2. The quality or grade of bituminous coal to be used. This has a marked influence upon the quality and class of labor required, the efficiency of the producer, the cost of the gas-cleaning apparatus, the cost of disposing of the tar, etc.

3. The charges in first cost to freight, and incidental expenses will obviously depend largely upon the location, shipping facilities, etc.

4. The load factor. The fuel consumption per brake horsepower-hour increases as the load decreases from full load. The other operating costs per brake horsepower also increase, though in different ratios.

As a result of these variable conditions each case should be treated in a more or less special manner to give the best satisfaction to the parties concerned.

The estimate does not include the cost of the water required for the plant. This may be easily determined for the particular case by allowing 10 to 13 gal. per b.hp.-hr. for the engine and 3 to 4 gal. per b.hp.-hr. for the producer.

The cost of the building and land is also omitted.

Determination of Size of Producer

The B.t.u. in the gas required per brake horsepower-hour from full load to three-quarter load is assumed to be 12,000.

$$300\ hp. \times 12{,}000 = 3{,}600{,}000\ B.t.u.$$

required in the gas per hour. Assume the producer efficiency to be 65 per cent.

$$3{,}600{,}000 \div 65\ per\ cent. = 5{,}538{,}461\ B.t.u.$$

in coal per hour. Assume the heat value of coal to be 13,500 B.t.u. per lb.

$$5,538,161 \div 13,500 = 110.25\ lb.$$

of coal per hour. Assume a gasification of 10 lb. of coal per square foot of grate area per hour

$$110.25 \div 10 = 11.02\ sq.ft.$$

of grate area. An internal diameter of 7 ft. 3 in. would satisfy this requirement.

Alternate method: As in the above case the B.t.u. required in the gas per hour equals 3,600,000. Assume gas at 135 B.t.u. per cu.ft. (low value).

$$3,600,000 \div 135 = 26,666.6\ cu.ft.$$

of gas per hour. Assume 65 cu.ft. of gas generated per lb. of coal per hour.

$$26,666.6 \div 65 = 110.25\ lb.$$

coal per hour. Assume a gasification of 10 lb. of coal per sq.ft. of grate area per hour

$$110.25 \div 10 = 11.02\ sq.ft.$$

of grate area, which is satisfied by an internal diameter of 7 ft. 3 in. This represents a gasification of 1.36 lb. per b.hp.-hr.

FIRST COST OF PRODUCER AND ENGINE

Producer @ $2 25 per hp	$675 00
Producer lining @ 0 25 per hp.	75.00
Labor for lining @ 0 10 per hp.	30 00
Blower for starting @ 0 10 per hp	30 00
Centrifugal scrubber @ 1 50 per hp	450 00
Intermediate scrubber @ 0 40 per hp	120 00
Tower scrubber @ 0.60 per hp.....	180 00
Piping and auxiliaries (blast) @ 0 50 per hp	150 00
Moisture separator @ 0.20 per hp...........	60 00
Water and gas piping @ 0 60 per hp	180.00
Filling for scrubbers @ 0.25 per hp..........	75 00
Erection @ 1 25 per hp........	375 00
Total..................................	$2400 00
Coal handling apparatus @ $6.00 per hp.	$1800 00
Total..	$4200 00
Add for starting up, auxiliaries, freight, travel, manufacturer's profit, etc., about 30 per cent. of $4200.00....................	1260 00
Total first cost of producer and equipment.	$5460 00
Cost of engine on foundation................	$13,000 00
Total first cost of engine and producer..........................	$18,460.00
First cost of engine and producer per hp..........................	$61 53

OPERATING COST OF PRODUCER

Coal gasified per hr. = ..	410 25 lb.
Standby loss, 2 per cent. of 410.25 = ...	8.20 lb.

From these figures any variation in loss in fuel due to shut-down of engine may be calculated.

Assume a special case calling for service 10 hr. a day for 313 days of the year; overhauling, etc., to be done Sundays and at night.

313 days @ 10 hrs. a day = ...	3130 hr.

3130 × 410.25 = 1,284,082 lb. of coal converted into power per year.

Total number of hr. per year = 8760

8760 — 3130 = 5630 standby hr.

5630 × 8.2 = 46,166 lb. standby cost per year.

Total consumption per year in tons of 2000 lb. = 665.12.

Coal—665.12 tons @ $2.00 per ton = ...	$1330 24
Repairs and maintenance @ 1.75 per cent. of 5460.00 = ...	95 60
Interest, depreciation, taxes, insurance @ 13 per cent. = ...	709 80
Supplies, about	30 00
Labor @ 4.00 per day (365 days)..................	1460 00
Total annual cost of producer = ...	$3625 64

OPERATING COST OF ENGINE

300 b.hp. for 3130 hr. = 939,000 b.hp.-hr.

First cost of engine erected on foundation = ...	$13,000.00
Depreciation @ 10% of 13,000.00 =	$1300.00
Supplies @ 0.03c. per b.hp.-hr. = ...	281.70
Lubricants @ 0.04c. per b.hp.-hr. = ...	375.60
Repairs and maintenance @ 0.15c. per b.hp.-hr	1408.50
Interest @ 5 per cent.........................	650.00
Annual cost of engine = ...	4015 80
Annual cost of producer = ...	3625 64
Total........................	7641.44

Power required to operate centrifugal scrubber is about 5 per cent. of total output.

Cost per year for operating scrubber = ...	382 00
Total annual operating cost of plant = ...	$8023.44
Total annual cost per b.hp....................	$26.74
Operating cost per b.hp.-hr.....................	0.85c.

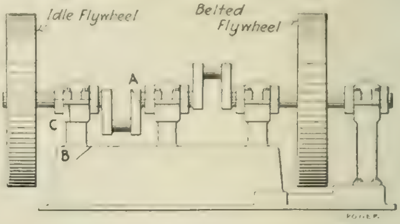
[The low cost per brake horsepower-hour of 0.85c. is due largely to the high load factor assumed during the hours of regular operation. The same method of figuring the results is applicable to other load conditions.—EDITOR.]

CORRESPONDENCE

Broken Crankshaft

Referring to the broken crankshaft described by **M. W. Utz**, in the Dec. 9 issue of POWER, and shown again herewith, the fact that the shaft broke at point *A* does not prove that the break was caused by an excessive torsional stress, but the writer is inclined to think that such stress combined with the possible disalignment may have contributed considerably to the failure.

The writer has never favored gas-engine designs of the type shown, where heavy flywheels are placed on both sides of the crank. If two flywheels must be used for the sake of bettering the balance, there is no good reason why the idle flywheel should not be made considerably lighter than the belted one. Where the idle wheel is just as heavy, it stores just as much energy as the other, and during the cycle in which it gives up its energy to the driven machine or machines that energy must be transmitted through a long, crooked shaft, as clearly shown in Mr. Utz's drawing. Where a load is suddenly applied, or in sudden binding or catching of the driven machines, as often occurs, there is a possibility of crankshaft failure, even though the load which is being pulled is light normally.



CRANKSHAFT, SHOWING LOCATION OF FRACTURES

Where a single flywheel is used, or where the idle wheel is small, this danger is practically eliminated. True, a gas engine looks better with two equal sized flywheels, even though the load which is being pulled is light normally

New York City. S. F. WILSON.

From the letter on "A Broken Crankshaft," printed in the issue of Dec. 9, page 825, it appears likely that synchronous vibration played a part in the accident. There would be two critical speeds for the engine, one affecting the torsional moment and the other the bending moment. The sketch looks as if the latter were the trouble. As a check to this it would be interesting to know if there were any signs of torsional fracture at *A*. The fact that the engine broke when carrying no load is strong evidence in support of synchronous vibration.

The engine was probably running below the critical speed normally. Some of the babbitt being wiped out of the bearing would weaken the directional restraining power of this bearing and consequently increase the period of natural vibration of the shaft or reduce the critical speed, making it come down to that of the engine speed or dangerously near to it.

JOHN AIREY.

Ann Arbor, Mich.

Refrigeration Department

Testing Ammonia Piping

By Gilbert Crawford, Jr.

Recently the ammonia pipe coils in a new freezing tank were in place before the compressor was entirely erected. It was desired to test these coils immediately so that the framework could be placed on the tank. As there was no air compressor available, the erectors had to find some method of getting a test pressure. Someone suggested that a little ammonia be injected into each coil in turn, and a test for leaks made with the ammonia. This suggestion was taken as a starting point and a plan was developed for the easy and economical testing of each coil with ammonia vapor pressure.

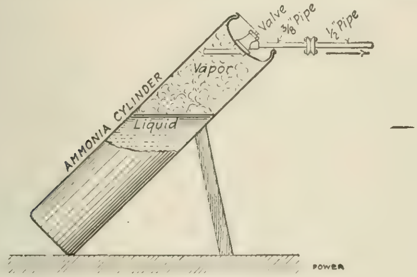


Fig. 1. Position of Ammonia Drum

Instead of attaching a cylinder of ammonia to each coil, a connection was made between the expansion valve of the first coil and the vapor space of the cylinder. In this way vapor could be passed into the first coil at a pressure corresponding to the temperature of the liquid ammonia in the cylinder. The cylinder was so placed that no liquid could pass out through its valve. In this way the minimum of ammonia was used to produce the pressure.

Fig. 1 shows how the cylinder was placed so that only vapor could be drawn therefrom. In the position shown, it was easy to make the necessary pipe connections to the first coil through the expansion valve X_1. Fig. 2 shows the general layout of the coils. The liquid header was not used for the test, and is not shown. The expansion valves, with the exception of that connected to coil 1, were used as blowoff valves, for allowing the air to be expelled from each coil. The expansion valves are represented by X_1, X_2, X_3, etc., while G_1, G_2, G_3, etc., represent the gas-return valves. The main gas-return valve is shown at G.

In making the test all the valves were closed except G_1, X_1 and G which was "cracked" a little. By opening the small valve at the cylinder, ammonia vapor passed into the first coil, driving the air before it out through G_1 and G. When ammonia was detected escaping at G, this valve was closed. The vapor from the cylinder continued to pass into coil 1 until the pressures were equalized. This condition was known to exist when ebullition ceased in the cylinder. Coil 1 was then carefully inspected for leaks, every joint being examined.

When it was certain that there were no leaks in coil 1 valve X_2 was opened slightly, then G_2. This allowed the pressure from coil 1 to drive the air from coil 2, after which X_2 was closed. After the pressure in coils 1 and 2 and the cylinder equalized, coil 2 was inspected for leaks.

For testing the next coil, a slightly different procedure was followed. Valve X_1 was closed, X_3 was opened a little, then G_3. Part of the gas from the first two coils passed into the third coil, driving the air ahead of it out through X_3, after which X_3 was closed. The gas pressures in the three coils now equalized at a pressure less than that in the cylinder. Coil 2 was cut off from the others by closing G_2. Then X_1 was opened and the pressure in the cylinder equalized with coils 1 and 3. Coil 3 was then inspected for leaks.

Coil 2 now contained gas at a pressure lower than that existing in the cylinder. By closing all valves, then allowing coils 2 and 4 to equalize, then shutting off coil 2 and opening up coil 3 until coils 3 and 4 were equalized, then shutting off coil 3, it was possible to fill coil 4 with gas at a pressure nearly equal to the cylinder pressure. The final increment of gas was supplied from the cylinder.

This method was followed with the remaining coils of the tank, so that at the end, the last and the first coils were filled with gas at the pressure existing in the cylinder, while the other coils contained gas at various lower pressures.

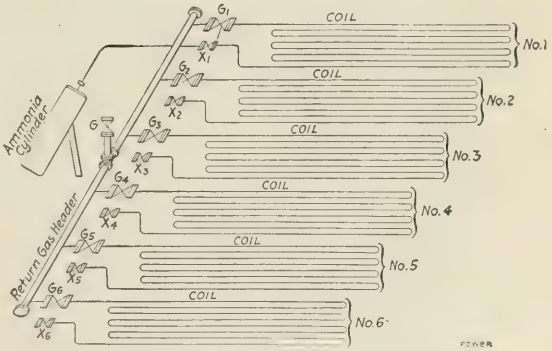


Fig. 2. Layout of Coils to Be Tested

As the liquid in the cylinder was at a temperature of 65 or 70 deg. F. at the beginning of the test, and as it did not cool much, a pressure in the coils was obtained of from 103 to 114 lb. per sq.in. gage. The coils in the tank amounted to 4800 ft. of 1¼-in. pipe, having an internal volume of about 50 cu.ft. This volume of gas at the above mentioned pressure, saturated, would weigh about 21 lb. As the gas was considerably superheated, and as all the coils were not filled with high-pressure gas at the end, no such quantity of ammonia was used.

Later on, to make sure that this test was complete, an air and ammonia pressure of 300 lb. per sq.in. was applied to the [illegible] and not a leak discovered. The cost of this test in time and ammonia was small, and the results were satisfactory.

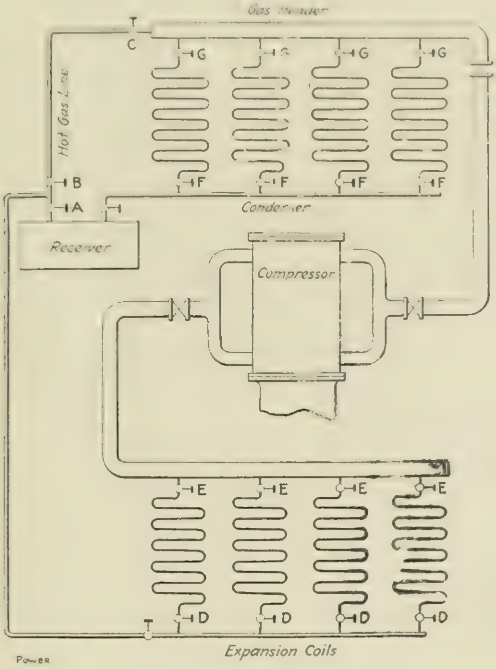
⁂

Removing Frost from Direct-Expansion Coils

By Thomas G. Thurston

As every engineer knows who has operated a direct-expansion system a heavy coating of frost on the expansion coils greatly reduces their capacity, the frost acting as an insulator the same as any other pipe covering. By far the best method to remove the frost is to pump hot gas direct from the machine into the coil or coils to be defrosted. The accompanying sketch shows connections for accomplishing this purpose.

A line is run from the gas header on the condenser, or from any convenient place in the discharge line from the compressor, to the liquid line. To remove the frost from a coil close valve *A* in the liquid line and pump the expansion coils and liquid line down to zero. Shut off the water from the condenser, open valves *B* and *C* in the hot-vapor line and let the hot gas blow through the liquid line until the liquid is blown out. This will be indicated by the frost disappearing on the low-pressure side of the expansion valves. Then close the expansion valves *D* on the coils which do not need defrosting, and on the coils from which the frost is to be removed close the suction valves *E* until they are barely cracked off the seat. Open the expansion valves wide on these coils and run the machine slowly. The frost will loosen and come off in a short time.



SKETCH OF LAYOUT

During these operations the condenser pressure must be watched as in a short time it is liable to run up high enough to blow the relief valves. If the condenser pressure runs up to the limit before the liquid line and coils are pumped down to zero, let it go at that, as it is not absolutely necessary to pump down to zero pressure. If the condenser pressure becomes too high while pumping hot vapor, turn sufficient water on the condenser to keep it down.

After the coils have been defrosted turn the water on the condenser, close the valves in the hot-vapor connection, close the expansion valves on the defrosted coils, open them on the other coils and open valve *A* in the liquid line at the receiver. After the machine is running normally open gradually the suction valves *E* on the defrosted coils, as considerable liquid accumulates in these coils during the cleaning process. If the valves are opened wide at once the liquid will be carried back to the machine before it evaporates and freeze the machine up if nothing worse.

Another and safer way to proceed after the coils are defrosted is to turn the water on the condenser, shut the valves on the hot-gas connection and open the expansion valves on the coils not cleaned. Then operate the machine and draw the liquid accumulated on the defrosted coils through the liquid line into the other coils until frost shows again on the cleaned coils. Then set the expansion valves on the latter coils for regular running, open their suction valves and the main liquid valve. This way of removing the liquid from the defrosted coils is safer than the method just described.

In case there is no hot gas connection, the hot gas can be pumped through one of the condenser coils and the liquid receiver by closing the liquid valves *F* between the condenser coils and liquid header on all the coils but one. Close the gas valve *G* on this coil and pump the coil, liquid header, receiver, liquid line and expansion coils down to zero if the head pressure will permit. The condenser coil which is used for this purpose should have the water drained from it in case the condenser is of the double-pipe type; otherwise it is liable to freeze while pumping out, or when pumping hot gas the water will condense some of the gas. After the system has been pumped out, open the gas valve *G* and proceed as before.

On a large number of modern compressors a separate pump-out line is run from the suction side of the machine to the condenser, liquid receiver and liquid line. In this case the pump-out line can be used for a hot-gas line. The section of the line to the compressor is shut off and a couple of valves opened on the pump-out line on the condenser coils and the pump-out connection to the liquid line. This allows the hot gas to flow through the condenser pump-out valves and the section of the pump-out line between these and the liquid line pump-out valve into the liquid line. This holds good only where the pump-out connection is at the top of the condenser. If it is at the bottom one of the coils will have to be pumped out and the hot gas pumped through it into the pump-out connection.

⁂

Alaska's Coal Development Retarded—The development of the coal resources of Alaska, according to the United States Geological Survey, has been held back on account of the lack of legislation permitting the exploitation of the known extensive and valuable fields. In 1912 the commercial product of coal in Alaska amounted to only 355 tons.

Editorials

Progress in 1913

Large is the word best suited to point out the tendencies of the year. In nearly every branch of the field units have been installed which are greater in capacity or size than ever before, and from all indications it would appear that present achievements have only whetted the appetite of manufacturer or user for a continuation in the same direction. The wonder of yesterday is only commonplace today and the future promises marvels up to the physical or efficient limits.

Early in the year the Inverness Railway & Coal Co. of Inverness, Cape Breton Island, ordered a Nordberg Corliss duplex double-drum hoisting engine, 34 and 34 by 72 in., designed to pull a 41,000-lb. load up a 10,000-ft. incline of 16 deg. at the surface and 35 deg. at the bottom. From the standpoint of rope stress and length of cable the hoist is thought to be the largest ever built, although a number of hoists with larger cylinders have been installed.

In Pittsburgh, a De Laval centrifugal pump having a rated capacity of 100,000,000 gal. per 24 hours against a total head of 56 ft. was ordered for the Ross pumping station. This is reported to be the largest steam-turbine-driven centrifugal pump in this country. Two immense Bethlehem Steel Co. pumping engines of the vertical triple-expansion high-duty type have been put in service at the new Mission Street station. Each pump has a capacity of 7,000,000 gal. per 24 hours, against a head of 495 ft.

The Mesta Machine Co. has built for the Gary works of the United States Steel Corporation, a 44 and 76 by 60-in. twin-tandem-compound geared reversing engine weighing 1000 tons and capable of developing the enormous output of 25,000 hp.

In boilers, those at the Delray station of the Detroit Edison Co. still hold the record for output and square feet of surface. Nominally they are rated at 2350 boiler horsepower on a basis of 10 sq.ft. of heating surface. It has been found possible to carry for an hour on a single unit, a load of 11,000 kw. In the Conners Creek station to be installed on Belle Isle, it is planned to use the same type of boiler with equal heating surface, but with the furnace modified so that it will be possible by forcing to continuously carry the enormous load of 13,300 kw. on one boiler. During the year a number of large boilers have been installed but none of them has over half the heating surface or steaming capacity of those at the Delray station.

Other large units of their particular type are a 5000-hp. gas engine, a 25,000-kw. alternating-current generator, a 3750-kw. direct-current machine, a Le Blanc jet condenser capable of condensing 150,000 lb. of steam per hour and a 10,000-hp. turbine at Keokuk, weighing 1,000,000 lb. The magnitude of the unit last named is measured in weight rather than in capacity as there are several hydraulic units developing twice the power.

Steam Turbines

It is in the steam-turbine field that the most rapid development has been made in the capacity of a single unit. Not long ago a 20,000-kw. unit was considered the last word in turbine design. During the year a unit of this size and one having a capacity greater by 5000 kw., have been installed and advance reports state that orders have been placed for four 30,000-kw. units and one having a capacity of 35,000 kw. In these larger sizes it is of interest to note that all are horizontal machines, even at the Fisk Street station of the Commonwealth Edison Co., of Chicago, where all of the previous units, aggregating 120,000 kw., are of the Curtis vertical type.

Naturally these giant units call for large auxiliaries. The condenser for the 25,000-kw. turbine mentioned above has 39,300 sq.ft. of tube surface which will condense 300,000 lb. of steam per hour, and the condenser for the 20,000-kw. unit has 35,000 sq.ft. With the former unit the usual air pump has been replaced by the kinetic air-ejector for the first time in this country. A small gain in vacuum means a great deal on so large a turbine and the operation of the new apparatus will be watched with interest. Temporarily the generator is the largest alternating-current machine in the field, and in connection with the plant there is an open feed-water heater having a capacity to heat 300,000 lb. of water per hour from a temperature of 65 to 130 deg.

Before passing from this station it may be of interest to state that a steam rate of 11.25 lb. per kw.-hr. at the normal rating of 20,000 kw. is expected of the larger unit. This betters by a little over one-half pound the remarkable rate obtained some two years ago on a 6000-kw Parsons turbine in the Dunston power station of the Newcastle-on-Tyne Electrical Supply Co.

In the smaller turbines the Terry Steam Turbine Co. has developed a multistage machine of the return flow type and the De Laval Co., a velocity stage turbine consisting of two or more regular De Laval wheels with a row of reversing blades between each pair. The mixed-pressure turbine has been given considerable attention. With its two sets of nozzles it will run with equal efficiency on high- or low-pressure steam and can be operated independently of the unit on which it depends for its supply of exhaust steam. In this feature it is an improvement over the usual exhaust-steam turbine.

During the last few months Europe has not been standing still. Ferranti in England has built a turbine of 3000 kw. capacity which runs on 9.4 lb. of steam per kw.-hr., or about 7.5 lb. per i.hp.-hr. LeBlanc in France is advocating a return to single-stage turbines running at very high velocities made possible by the new high-tensile strength steels. Schmidt, the superheater man, is making experiments with very high pressures and temperatures that promise results for steam comparing favorably with those of the internal-combustion engine.

Engine Progress

In reciprocating engines there has also been advancement. Perfection of design and construction has resulted in some remarkably low steam rates and the use of superheated steam in an engine of the poppet-valve type has made possible a rate of 15.24 lb. per i.hp.-hr., noncondensing. The old reliable and efficient Corliss is still in the field and will be for years to come, but the tendency is away from this standby of two generations and toward the high-speed engine and some of the recent importations from Europe built on the Lentz and Unaflow principles. The year has also seen the first American locomobile which, on test, has developed an indicated horsepower-hour on 9.65 lb. of steam and 1.51 lb. of Holwick coal.

A number of rotary engines and so-called rotary air-pumps have "seen the light" and there has been a new design of triplex pump in which cams take the place of cranks in producing the reciprocating motion.

Electrical Advancement

Perhaps the most important new development during the past year in the electrical field, was the half-watt nitrogen-filled tungsten lamp brought out by the General Electric Co., as a result of several years work by Dr. Irving Langmuir. There has been little change in generators and motors except in the size of the former to keep pace with the increasing capacity of steam turbines. The largest alternating-current generator installed during 1913 was a 25,000-kw. machine at the Commonwealth Edison Co., of Chicago, although still larger ones have been ordered, and the largest direct-current machine, having a capacity of 3750 kw., was installed at the Canal Road plant of the Cleveland Electric Illuminating Co. For alternating-current transmission, 150,000 volts still remains the upper limit, work on the Big Creek Development in California, at which this is employed, having progressed steadily during the past year. In direct-current transmission, however, a bold step was taken in the decision to employ the Thury system at 90,000 volts to transmit 20,000 kw. from the Trollhattan Falls in Sweden to Copenhagen, Denmark.

Water Power

The two most notable hydroelectric developments which were formally put in operation during the past year in this country are the Mississippi River Company's plant at Keokuk, Iowa, and the Hales Bar Plant on the Tennessee River. The former is notable chiefly because it will ultimately be the largest single water-power development, aggregating about 300,000 hp., although the immediate plans call for only 150,000 hp. The Hales Bar plant, although designed for only 44,000 kw., possesses a number of unusual features and was completed only after eight years of labor, during which a chain of unforseen difficulties was encountered, making the initial cost greatly exceed that estimated.

Work on a number of smaller hydroelectric developments has been started and several of the existing systems have been extended. Among these may be mentioned the Appalachian development on the New River, Va., consisting of five plants, aggregating 75,000 hp., two being already completed; the New England Power Company's developments on the Deerfield River, four plants being completed and a fifth under construction; a 12,000-hp. plant on the Coon Creek Rapids near Minneapolis; the Turner's Falls development on the Connecticut River; and in the Pacific Coast states extensions to the systems of the Washington River Power Co., the San Joaquin Light & Power Co. and the Pacific Gas & Electric Co. The last named company now has sixteen plants, steam and water power, totaling about 300,000 hp. In Switzerland construction has been started on a 5312-ft. head plant which holds the record as the highest head thus far to be developed.

The Gas Engine

Among special applications in the gas-power field, Professor Hopkinson's method of cooling gas-engine cylinders by direct injection of water onto the piston and exhaust valves, has attracted widespread attention. Dr. Low, in England, is still experimenting with his internal-combustion engine into which coal is fed directly. In the original design, tubes containing coal extended across the explosion chamber, the gas being driven off from the coal by the heat surrounding the tubes and drawn into the chamber. Spiral conveyors extended through the tubes and by their rotation urged the coal forward. In the later design these conveyors, which lost their rigidity under the high temperature, are abandoned, and the pipes made larger and vertical so that the coal feeds forward by its own weight.

The installation of Humphrey gas pumps for the Metropolitan Water Board has been completed and is now in operation. Last summer also marked the installation of the 5000-hp. gas engine (the largest in this country) at the plant of the Ford Motor Co., Detroit. The first Diesel locomotive was also completed by Sulzer Bros. of Winterthur, Switzerland, and put in service on the Prussian-Hessian State Railway.

In last year's review we called attention to a number of semi-Diesel engines that were being advanced by American manufacturers. The past year has seen several well known American firms take up the building of heavy oil engines of the regular Diesel type.

Refrigeration

During the year the refrigerating field has been given a number of new tables on the properties of ammonia. Perhaps the best of these was the set issued by the Engineering Experiment Station of the University of Illinois. More accurate experimental work than has been conducted in the past may render necessary some revision of the tables, but within the limits of practical working they may be safely accepted as standard.

The Bureau of Standards at Washington has been making some interesting tests to determine the latent heat of ice, and have found that a value of 143.5 B.t.u. per lb., instead of the 144 B.t.u. now used in this country, is approximately correct. The bureau is to continue its good work. Apparatus is now ready for making tests on the resistivity of insulation, and there will also be some work on the properties of ammonia and perhaps some of the other refrigerants commonly used. Pennsylvania State College now has a large thermal testing plant and in the past year has been testing some of the standard forms of insulation. Accurate standards have been badly needed in the refrigerating field so the work now under way should prove of immense benefit. The Third International Congress of Refrigeration held recently in Chicago afforded Americans the opportunity of a generation. Engineers from twenty different countries met and discussed topics of pressing interest and a more uniform and concentrated effort in advancing the art is to be expected as a direct result.

Marine Tendencies

On the high seas nothing of any great import has come to pass. The quadruple-screw turbine-driven Hamburg-American liner "Imperator," with 62,000 hp for driving her propellers and 203,000 sq.ft. of boiler-heating surface, was put into service. The 20,000-ton collier "Jupiter" of the United States Navy also went into commision. She is equipped with a high-speed Curtis turbine, the first of a type, and the reduction in speed for efficient propeller operation is accomplished electrically, The turbine drives a 5450-kw., two-pole generator which supplies current to two 2750-hp., 36-pole motors, so that the ratio of reduction is practically 1 to 18. Test data from this ship may possibly have some influence in reconverting navy officials to turbine propulsion.

Oil fuel is fast becoming a question of urgent importance to the navy. Last year 30,000,000 gal. were used and in the near future it is likely that this amount will be increased over fourfold. Within the last month Secretary Daniels has recommended that the navy secure its own oil wells and do its own refining. A constant supply at a low cost would then be assured and the exclusive use of oil fuel might be adopted with reasonable security.

Engineering Societies

Among the various engineering societies in this country the American Society of Mechanical Engineers has had a very successful year. The attendance is increasing, more papers of a high standard are being presented and the standing committees are doing excellent work. The old question of flanged fittings was up at the annual meeting. The committee had formulated a compromise with the manufacturers which would do away with the dual standard, but a vote before the society as a body resulted in laying the matter over until the next meeting. At the invitation of the Verein deutscher Ingenieure, 300 members and friends of the society attended the spring meeting of the German society at Leipzig. The visitors were taken all over Germany in a special train, their entertainment including fifteen formal banquets and receptions, fourteen lunches and collations, twelve concerts and lectures, and special performances and ten excursions by rail or boat.

Boiler and Flywheel Explosions

Boiler accidents and explosions in this country for the first six months of the year total 234, in which are included stationary, marine, locomotive, portable and heating boilers. Those killed number 68, and 234 were injured. Assuming that the last six months will duplicate these figures, the totals for the year will be 468, 136 and 468, respectively. Besides there were three economizer explosions, killing six and injuring twenty. There were also a number of steam-pipe ruptures, air- and elevator-tank explosions, cylinder-head breaks, etc., which in the Hartford Co.'s compilations are usually included under the broad head of "boiler explosions." With these items included, the records for 1912, in the same order as before, give 537, 278 and 392. That the number of heating-boiler explosions was particularly large would indicate that more attention should be given to the inspection of this type of boiler. The flywheel explosions totaled about fifty for the year, and from the records of the first eight months the death list should be about twenty, with serious injuries to thirty more.

License and Inspection Laws

Year after year the list of fatalities reaches this same high limit or perhaps exceeds it, and relief from this inexcusable slaughter cannot be expected until every state in the Union has stringent license and boiler-inspection laws which are intelligently enforced. There has been agitation in quite a number of the states, but the net results appear to be an engineer's license law for California, a boiler-inspection law for Indiana, revised laws for Montana, a license law for New Jersey, and new boiler regulations for the province of Ontario. With the aid of the National License Committee of the National Association of Stationary Engineers other states will no doubt soon fall in line, and the recent adoption of standard boiler specifications by the National Association of Tubular Boiler Manufacturers should also help on the side of safety.

Blazing the Way

Appropriations for the fiscal year ending June 30, 1915, asked by the Bureau of Mines, indicate that it is to continue on an increased scale its valuable work relating to fuel and mines. Of this $135,000 is to be devoted to fuel testing, $10,000 for the equipment of a testing plant and $30,000 for investigating petroleum and natural gas.

At last it would appear that some attention is to be given to the achievements of science and industry. The land is full of libraries, there are museums of natural history and art, but there is nothing worthy of the name to record and exhibit the "milestones" in engineering development. Steps have recently been taken to found a group of museums in New York City, "The Museum of Peaceful Arts," which will consist of twenty buildings costing $30,000,000 and requiring two to three million per year for maintenance. It will be divided into branches on electricity, steam navigation, safety appli ances, mechanical arts, mining, architecture and other subdivisions of equal interest and usefulness. The idea is splendid and if carried through to completion, will result in great good to the fields represented.

Isolated Plant vs. Central Station

Much in the same way as in previous years, the central station and isolated plant are carrying on their fight for supremacy. It is becoming evident to both sides that there is a field for both, and that the decision placing a plant in either must be based on accurate records and statistics fair to both sides. Probably the most comprehensive test ever conducted is that just completed by representatives of the City of New York and the Edison Co. The plant in the Hall of Records has been the scene of action, and for a full year a complete plant test has been under way. Complete operating data will be available for all seasons of the year, and upon these figures it will be decided whether the city is to continue to generate or buy its current. That municipal operation of a power plant is practical and that efficient results may be obtained in such a plant has again been shown in Pasadena. The sixth annual report on this plant, published in our issue of Oct. 28, contains some interesting facts.

THE HONOR ROLL

Among the men honored in the mechanical field were George Westinghouse, who was awarded the Grashof medal; Prof. H. K. Onnes, of Leyden, given the Nobel prize in physics, and Prof. A. Werner of Zurich, the prize in chemistry. The following men were elected as presidents of the various engineering societies in this country, relating to the field: James Hartness, president of the American Society of Mechanical Engineers; C. O. Mailloux, president of the American Institute of Electrical Engineers; Joseph B. McCall, president of the National Electric Light Association; James R. Coe, president of National Association of Stationary Engineers; John F. Hale, president of the American Society of Heating and Ventilating Engineers; Henry Torrance, Jr., president of the American Society of Refrigerating Engineers.

NECROLOGY

Those of prominence who passed away during the year just closed were the following: Victor Hugo, manager and chief inspector of the St. Louis department of the Hartford Steam Boiler Inspection & Insurance Co.; John Fritz, famous in the steel industry; Dr. C. G. P. de Laval, inventor of the turbine and separator bearing his name; William Henry White, a professor of naval architecture and originator of the modern battleship; W. H. Fletcher, vice-president of the Consolidated Iron Works; Philip H. Diehl, founder of the Diehl Manufacturing Co.; Victor Dwelshauvers-Dery, a distinguished scientist noted for his researches into the properties of steam and its action in the engine cylinder, and his work for the advancement of engineering education; James Tangye, one of the Tangye brothers so well known in English mechanical circles; Samuel L. Moyer, first vice-president and general manager of the Lunkenheimer Co.; Francis M. Rites, inventor of the inertia governor bearing his name; Horatio A. Foster, author of the "Electrical Engineer's Pocket Book" and chief appraiser for J. G. White & Co.; Horace Greeley Burt, ex-president of the Union Pacific R.R. system and later chief engineer of the Chicago Association of Commerce Smoke Abatement Committee; Stephen D. Field, inventor of an electrical elevator and electrical devices relating to telegraphy; Bernard Schuchardt, head of the well known firm of Schuchardt & Schütte; Anthony N. Brady, president of the New York Edison Co. and a number of other corporations; Eugene O. Reuleaux, general superintendent of the American Rotary Valve Co.; Dr. Rudolf Diesel, famous through the invention of the engine bearing his name; William Cary Seldon, a consulting mechanical engineer who had much to do with the early development of steam navigation in the United States Navy; George C. Karme, secretary of the Hills-McCanna Co.; John F. Ensign, chief of the division of locomotive-boiler inspection of the Interstate Commerce Commission; Edwin T. Moore, secretary and treasurer of the Coatesville Boiler Works; Charles Tellier, familiarly known as the "father of refrigeration"; Edgar Penney, president of the American Society of Refrigerating Engineers in 1908; A. J. Frith, associate professor of mechanical engineering at Armour Institute, Chicago.

Concerning the "Imperator"

As noted elsewhere in this issue, it is but natural that much interest should be shown in such a large and elaborately equipped vessel as the "Imperator," and that curiosity should be excited by the vessel being ordered into dry dock for extensive repairs after seven months of service. As all who read the daily papers know, there have been many rumors as to the real reason why the vessel was taken out of service. While the American office of the ship's owners emphasizes its lack of knowledge concerning the vessel's troubles, the home office cables protesting denials of all rumors..

As Hamlet said of the lady, the company protests too much, we think. Surely there is nothing so very seriously wrong with this object of universal interest. The curiosity of engineers is not morbid; it is professional. Perhaps the German office does not appreciate the interest American engineers take in this ship. If it did, it would enlighten and not mystify.

⁂

One of the most beneficial developments that the power plant can sustain will be passing of the "fireman" and the coming of the combustion engineer, as has already been the partial replacement of the engine tender by the engineer.

⁂

That is a good suggestion, Mr. President, from the American Institute of Consulting Engineers, that one or more engineers be appointed upon the Interstate Commerce Commission. The time is ripe for the recognition of the worth of an engineering training for positions of this kind, and the profession contains men who would bring to the commission dignity and poise as well as real ability. It must be refreshing, too, to have a suggestion for an appointment from a body of men who have no candidate to urge.

⁂

When the recommendation is openly made in the forum of the American Society of Mechanical Engineers that the legislatures of the several states pass uniform laws governing the construction, installation and operation of steam boilers, and when the American Boiler Manufacturers' Association and the National Association of Tubular Boiler Manufacturers are actively advocating the passage of such laws it begins to look as if the legislators would have to sit up and take notice. What has become of the effort to get the National Commission for Uniform State Laws interested in the subject?

⁂

An appropriation which should find favor in the eyes of legislators who have the interest of the people at heart is that requested by the Department of Commerce (Bureau of Standards) for the investigation of the standards and methods of measurements, and for determination of the quality and cost of service required in the regulation by states and cities of public utilities, such as the electric light and power companies, city and interurban railway companies, telephone companies, gas companies, water companies and every public utility company, and for furnishing technical data and expert advice to state and city officials upon request in connection with the regulation or operation of public utilities, or of thefulfillment of municipal contracts for street lighting, water, gas or electric power, etc.

Readers with Something to Say

Discovered Large Crack in Boiler

Reading the article on boiler explosions and inspection in the Nov. 25 issue of Power, page 716, reminds me of a near explosion in a plant where I was chief engineer.

On taking charge of the plant I found three boilers working under 90 lb. steam pressure, furnishing steam to a 14 and 26 by 42-in. tandem-compound engine operating a 2,000,000-gal. pump for water-works. On examining the boilers I found a slight leak near the lap seam, the steam issuing, apparently, from around the rivet. I asked the retiring engineer about it and he said the old boiler had been leaking for six months and he had nearly beat the head off the rivet trying to stop the leak. After a closer examination I found that the steam was coming through a crack in the boiler plate and at once had the boiler cut out of service, which brought the manager down on me in no uncertain terms, as the plant was seriously crippled without the boiler. I pointed out to him the danger of an explosion and he agreed to wire for an inspector, who arrived the next day. We put the boiler under a hydrostatic pressure of 90 lb. and a little water came out through the crack. The inspector struck the plate with his hammer and it opened for 5 in. right along the seam, and internal inspection was then made and seven crowfoot stays were found broken. A boiler maker was called in and after cutting out a strip of the plate a crack 28 in. long was found on the under side and hidden by the lap seam.

Just how long it would have been before the boiler would have exploded is a matter of speculation, but I think that any practical man will agree with me that it would not have been long.

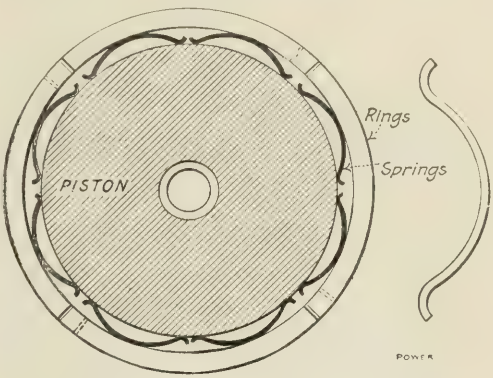
H. McGiboney.

Middlesboro, Ky.

Piston Rings Wear Cylinder

Concerning the trouble A. M. Robb is having with pump-piston rings wearing, as told in the Nov. 11 issue, page 692, it is not stated whether the rings are cast iron or not, nor whether the lining of the cylinder is brass which would have a great deal to do with its wearing qualities. The pressure, 160 lb., is too high for packing, as it will cause undue friction and cutting, especially if the rings and lining are of the same material. This case is different from a steam cylinder in that there is more or less grit present in the water, and that there is no oil used to lubricate the rings as is done in a steam cylinder. I would suggest that the edges of the ring be well rounded off, and that the holes be all plugged up and flat springs be used under the rings as shown in the accompanying sketch. This ring is made in four segments with the ends lapped, and with two or more springs under each segment. The springs are long enough to entirely fill the space with a short dowel pin between each one to prevent them from getting out of place. This method of packing gives an even pressure on the entire surface, and can be made strong or weak as desired. The ring should be of a different metal than the cylinder lining, as it will give less friction than two metals of the same kind.

There are some steam engines the pistons of which have rings set out by the steam pressure, but the cylinder requires more oil and the wear on the ring and cylinder is uneven in the cylinder as the pressure on the ring is greater at the beginning of the stroke than it is after cut-off takes place. The pressure in the steam cylinder would be less against the ring than in the pump, and I do not believe the type of piston he mentions will give satisfactory results in a water cylinder.



Section of Piston, Showing Rings

J. C. Hawkins.

Hyattsville, Md.

Slippage of Reciprocating Pumps

The article by M. K. Baer, on the above subject, appearing in the Apr. 8 issue, and the replies thereto, in the June 3 issue, have just come to my attention. The synopsis of this article says that it is folly to assume a general figure of 5 per cent. as the slippage of reciprocating pumps and the slip may be anything from 5 to 85 per cent. Thanks are due Mr. Baer for having brought up this question for discussion and it is to be hoped that other opinions will follow.

My opinion is that slip can only be stated for a pump in good condition. This is in line with the rule followed in making other tests. Nobody would think of basing the strength of some material on a defective test bar. Defects in design, material, workmanship, or due to wear are exceptions to the rule and must be remedied, but not pointed out as normal. Mr. McMillan expresses the same sentiment in saying that by keeping a pump in proper repair the slippage can be kept within a range of from 2 to 5 per cent. throughout the year.

The tests given in the article all show high slippages such as should not have been tolerated for any length of time. The 16 and 9 by 12-in. fire pump is stated as having a clearance of 0.02 in. Good workmanship demands that the clearance of a plunger of this size should not exceed 0.001 in. in diameter or $^1/_{20}$ of the actual play. This would have reduced the slip to some reasonable amount.

No description is given of the 7½ and 4½ by 6-in. pump, so I assume that it was a pump with an improperly packed piston. To pack a piston just right is a difficult job. It must be tight enough to prevent leakage and yet not so tight as to produce undue friction. It is difficult to judge from outside appearances when this condition prevails. A packed piston may look nice on a drawing and be theoretically perfect, but in practice it is frequently far from this condition. A plunger and ring, on the other hand, is theoretically slightly imperfect and is looked upon by many with contempt for this reason. In practice, however, it is not any more imperfect than the packed piston and can be depended upon to last for a long time. So while a newly and properly packed piston pump may show less slip than a plunger and ring pump, the slip will rapidly increase while in the latter it will remain constant. The slip, therefore, largely depends upon the condition and cannot be stated by any rule or formula.

As mentioned in the article the slip is also dependent upon the speed, since the rate of leakage is practically constant and if expressed in per cent. of the capacity will be greater at reduced capacity. If the slip at full capacity is 5 per cent., then at half capacity it will be 10 per cent., and by continuing to reduce the speed a point will be reached where the slip is 100 per cent. This law is utilized in testing small pumps. The discharge valve is closed and sufficient steam pressure is admitted to obtain the normal water pressure. If the speed is then about 1 per cent. of the normal, the pump is passed as satisfactory. Thus a 6 and 4 by 6-in. pump, the normal speed of which is 65 ft. per min., will pass the test if it does not run much over 0.65 ft. per min. with closed discharge. For the sake of convenience this speed is expressed by the number of single strokes per minute and is called "lost actions." A pump with a 6-in. stroke makes 260 strokes per minute and will therefore pass with three lost actions. Here is a pump in perfect condition showing a slip varying from 1 per cent. at full load to 100 per cent. at $^1/_{100}$ load. Pumps handling large amounts of water have frequently shown no slip or even negative slip, which means a volumetric efficiency (1 — slip) of over 100 per cent. This was due to the fact that the water continued to flow after the plunger had stopped. The range of slippage could therefore be extended considerably and be made to look still more formidable.

Mr. Newbold's formula does not seem to agree with practice. The accompanying table calculated by this formula shows that pumps of 4-in. stroke and under do not pump any water at all, while as a matter of fact thousands of them are in successful operation. The formula is

$$x = \frac{\sqrt{P} \times 2000 \times G}{L \times S}$$

where

x = Percentage of slip;
P = Pounds pressure of the liquid;
G = Specific gravity of the liquid;
L = Length of stroke in inches;
S = Piston speed in feet per minute.

With 150 lb. as the pressure of the water and the specific gravity 1, the formula reduces to

$$x = \frac{24{,}500}{L \times S}$$

Using this formula the various percentages of slippage given in the table were obtained.

SLIP AS OBTAINED FROM FORMULA

L Stroke, in.	S Speed, feet	x Per Cent.
3	40	201
4	50	122
5	60	82
6	65	63
8	75	41
10	80	30 6
12	90	22 7
15	100	16 3
18	110	12 4
24	120	8 5
36	135	5
48	145	3 5
60	150	2.7

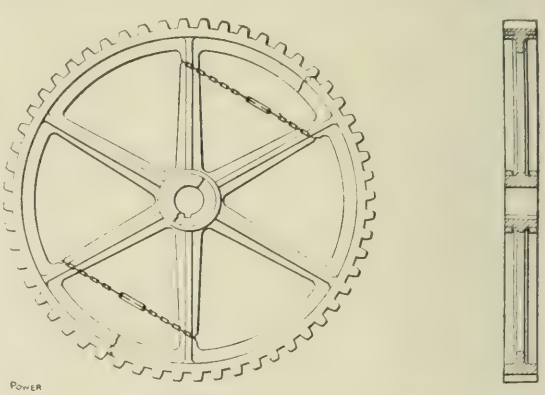
F. F. NICKEL.

East Orange, N. J.

*

Quick Repair to Broken Wheel

Recently a serious breakdown occurred to one of our electric hoists that hauls coal up from one of our dip entries. While running at full speed around a curve the wagons left the track and ran into an obstruction, breaking the rope and at the same time breaking the large gear wheel on the drum shaft, completely in two, the pieces falling into the wheel pit. The accident happened while making the last trip, and the broken wheel was not discovered until the night shift went on duty. The hoist is nearly a mile and a half from the pitmouth, and as we had no duplicate of this wheel and could not afford to lose much time, we had the pieces brought out to the blacksmith shop, and laying them on the floor, we leveled them up so that the fractures would come well together. We then put a piece of ½-in. chain with a 1-in. turnbuckle around two of the arms on each side of the hub as shown, cutting a nick on the arms to prevent the chains from slipping. We then shrunk a strong ring on each side of the hub. This pulled the wheel together until the cracks were hardly perceptible. We drilled some holes in the rim of the wheel right in the cracks, tapping the holes for ¾-in. bolts, on both sides of the wheel and later pulling the bolts up tight to prevent any side movement of the parts of the wheel.



CRACKED WHEEL HELD BY CHAINS

The dimensions of the wheel are as follows: Diameter, 68 in.; width of face, 6 in.; length of hub, 8 in.; bore, 5 in. It was nearly midnight when we got the wheel outside the mine and we had it repaired and back in place again in time for the next day's run, which we consider a quick repair job. The wheel is still running and has not given any signs of weakness, although it has been in operation for over six months.

T. D. Parfitt.

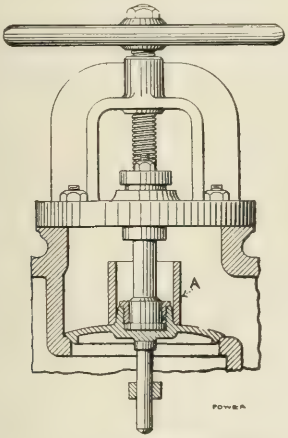
Claridge, Penn.

Reducing Valve-Stem Wear

The sketch shows how I stopped the chattering of the disk of our 8- and 6-in. globe valves which had worn off the ends of the valve spindles, so severe was the chattering. We have had five shutdowns in parts of the plant, owing to accidents of this nature.

Various means of stopping the chattering have been tried with varying degrees of success, but the means herewith described has proved the best.

The valve stem was screwed out of the hood and a piece of 2-in. pipe *A* about 1½ in. long placed on the stem between the hood and the top of the disk, the pipe going over the nut that holds the disk to the stem. When the valve is opened the stem is screwed out so that the collar of pipe on the stem is held tightly between the bonnet and the disk. This, of course, prevents any movement of the disk and consequently the end of the stem is not worn and there is no more chattering.



Pipe Collar Prevents Wear of Valve Stem

Harry Biehl.

Philadelphia, Penn.

Water in Engine Cylinders

The article describing the experiments of H. Bollincks with water in engine cylinders, as published in the Aug. 26, 1913, issue, reminded me of my own experience.

After warming a 14x30-in. Corliss engine, which I had just taken charge of, I started it slowly, but it had not made more than ten revolutions when there was a loud report in the cylinder followed by heavy blows at each stroke. Investigation revealed that water had accumulated in the exhaust pipe which was not provided with a drain as it formed a trap or pocket between the heater and engine cylinder, and caused the piston rod to punch through the follower plate.

I believe that if the engine had been started quickly it would have discharged the water from the cylinder without doing damage. The reason I believe this is because of another experience related below.

The fireman had flooded the boiler and much water was being carried to the engine. At the time I was on the second floor of the factory repairing a line shaft when my attention was called to the slugs of water coming from the end of the exhaust pipe. Rushing to the engine room, I shut down and was surprised to find that no damage had been done.

Paterson, N. J. Peter Vandenberg.

Graphite Reduces Scale Formation

Having read the various articles and comments on the use of graphite in steam boilers, I am moved to relate my experience.

The scale evil has always been serious with us, and seemed nearly impossible of prevention. We have two 120-hp. horizontal return-tubular boilers in continuous service from June until Sept. 20, both boilers being run at full-rated capacity. The conditions make this service necessary. As an illustration of the amount of scale taken from the boilers after such runs, my records show that at the end of the 1912 season, 350 lb. of scale was removed from each boiler.

On June 16 and 27, 1913, Nos. 1 and 2 respectively, were put in service, each having graphite fed in but not strictly according to directions. No. 2 boiler gave 25½ lb. of scale when it was cleaned on Oct. 14, and No. 1 gave 49 lb. There still remains a little scale in each boiler which is expected to come off at the next cleaning.

Fearing that the scale might be thrown down in such quantities as to bag the shell, I fed in daily only one-fourth the amount specified in the directions.

Frank C. B. Speare.

Cape May City, N. J.

Fixing the Blame

The editorial with the above title in Power of Nov. 18 suggests a condition worthy of mention. Some four years ago considerable trouble was had by a company in operating its boilers. The tubes were continually being replaced, because of corrosion. At length the makers of a boiler compound overcame the trouble by supplying a barrel of their compound, and everything went on smoothly for about two years. Then the company hired another superintendent.

This man, a young college graduate, stopped the use of the compound and began using graphite. In a year's time, when the annual internal inspection became due, one of the boilers was so badly corroded at the tube headers and the nipples that the insurance company canceled its policy and condemned the boiler.

The owners are still operating this boiler, however, and while they are using a much more expensive compound, it is not doing any good. Furthermore, it is believed that the other boilers in the plant will be condemned at the next inspection. Here is a case where there should be some authority to which to appeal before the condemned boiler explodes and perhaps destroys many lives.

Hazleton, Penn. A. G. James.

Inquiries of General Interest

Load Factor—What is meant by the term "load factor"?

J. W.

The generally accepted definition of "load factor" and the one adopted by most large power companies in this country, is the ratio of the average power to the maximum power during any given period.

Emery Around a Dynamo—Why should emery-cloth or paper not be used on a dynamo commutator?

W. N. J.

Emery is objectionable around a dynamo because its loosened grains are likely to get in the bearings and start cutting. It is better to use fine sandpaper as any loose flint getting into the bearings becomes ground up and discharged and is much less likely to set up cutting of the bearings.

Gas Heat Value—Is 120 B.t.u. per cu.ft. a good heat value for producer gas? In such a statement, the gas is presumed to be under what pressure, for the heat value per unit of volume must vary with the pressure?

H. H.

A value of 120 B.t.u. per cu.ft. of producer gas is low, as average producer gas would be about 140 B.t.u. per cu.ft. Unless otherwise qualified, statements of heat value per cubic foot are based on the density of the gas when at atmospheric pressure.

Boiler Compound—What is the composition of the Navy Standard Boiler Compound?

G. H. B.

This is a powdered compound composed of at least 64 per cent. of anhydrous sodium carbonate (Na_2CO_3), 15 per cent. of tri-sodium phosphate ($Na_3PO_4 \; 12 \; H_2O$), 1 per cent. of dextrine or starch and 10 per cent. of a tannin compound such as mangrove bark, cutch or catechu, containing at least 35 per cent. of tannic acid. By thorough digestion these materials are intimately united, then dried, finely powdered and well mixed.

Injection Water for Oil Engines—What is the purpose of injecting water into the cylinder of an oil engine?

J. V. H.

For suppressing the force of the explosion and for permitting a higher compression without danger of preignition. In some instances, this water is injected into the cylinder separately; in others, where a light oil such as kerosene is used with a carburetor, water is sometimes injected along with the mixture from the carburetor. There is still another purpose of water injection, which was devised by Prof. Hopkinson, and described in "Power" for Spt. 2, 1913, wherein the water takes the place of the cooling jacket, and is impinged in slugs upon the head of the piston and on the exhaust valve.

Increasing Weight of Governor Balls—What effect has increasing the weight of the fly balls of a simple pendulum governor?

F. D.

Neglecting the weight of the arms, links and collar, which is small usually compared with the weight of the balls, increasing the weight of balls has no effect on their position for a given speed and consequently has no effect in changing the speed of an engine. The weight of the collar tends to keep the balls lower and retard the action of the governor. When the collar carries a weight, then an increase in weight of the governor balls increases the lifting power of the governor and has the same effect as taking load off the collar; i.e., the balls rise to cutting-off position of the governor for less speed and the engine is regulated to a slower speed.

Relative Coal Consumption—Why should more coal be used for driving our flour mill with an 18x42-in. Corliss engine during the night shift of 12 hours than when using the same engine and a 12x30-in. Corliss during the 12-hour day shift? The engines are belted to separate loads.

J. F. M.

The actual load and the uses of steam during the night shift may be greater than during the day shift. The facts should be ascertained by indicating the engines and inspecting all drafts of steam from the boilers and noting all operating conditions, each at intervals of about 30 min. during at least 24 hours. If such observations do not account for the discrepancies, they may be due to starting the day shift with high water and fresh fires and starting the night shift with low water and low fires and charging a disproportionate amount of coal to the night shift, or there may be a difference in firing.

Cost of Electric Hoisting—An electric crane lifts 3000 lb. 37 ft. Neglecting friction, motor efficiency and power consumed on the down trips, what would be the cost of handling 720 such loads, with current costing 3c. per kw.?

J. W. B.

One kilowatt-hour is equivalent to 2,654,200 ft.-lb. per hr. The net energy required to lift one load of 3000 lb. 37 ft. would be

$$3000 \times 37 = 111{,}000 \text{ ft.-lb.},$$

and, therefore, a service of 1 kw.-hr. would raise

$$\frac{2{,}654{,}200}{111{,}000} = 23.9 \text{ loads}$$

At 3 cents per kw.-hr. the cost of current per load would be

$$\frac{\$0.03}{23.1} = \text{about } \$0.0013$$

and 720 such loads would cost

$$720 \times \$0.0013 = \$0.93\tfrac{6}{10}.$$

Gas-Meter Correction—Will a gas meter, calibrated for a pressure of 1½ in. of water, pass three times the quantity for every cubic foot registered when the actual pressure is 4½ in.?

H. H.

No. Gas pressure, stated in inches of water like gage steam pressure, is the pressure above the atmosphere. The latter being 14.7 lb. per sq.in. abs. (i.e., above vacuo), is equal to a pressure due to a column of water,

$$33.947 \times 12 = 407.364 \text{ in.};$$

hence the absolute pressure equal to 1½ in. water pressure above atmosphere would be

$$407.364 + 1.5 = 408.864 \text{ in. of water abs.}$$

At 4½ in. water pressure above atmosphere, the absolute pressure would be

$$407.364 + 4.5 = 411.864 \text{ in. of water, abs.};$$

so that one cubic foot at 4½ in. water pressure above atmospheric pressure would be equal to $\frac{411.864}{408.864}$ or 1.0073 as much as at 1½ in. water pressure above atmosphere, i.e., at 4½ in. water pressure there would be not quite ¾ of one per cent. more weight of gas per cubic foot than at 1½ in. water pressure.

Tube Baffling—Is it necessary to cover the top and lower side of the bottom row of tubes in a Heine boiler and the same of the top row of tubes, i.e., should these tubes have tile completely around them?

E. F. M.

Where such a boiler is fired by mechanical stokers or with a forced draft or both, for the better protection of the lower row of tubes, the baffle bricks are made to completely encircle these tubes. But where hand firing and natural draft are used, it has been found advisable to cover only the upper side of the lower row of tubes, especially where the coal tends to form stalactites, that is, deposits hanging from the brick, because in cleaning off the lower side of the tubes, or in the operation of hand firing, the undersides of the bricks, when exposed, are likely to be broken. This would allow the fire to go up in between the bricks like a "blow-pipe flame" causing excessive heat or local burning, which is detrimental to the tubes. The firebrick on the upper row of tubes is intended to act only as a baffle and at a point where the fire flame is not so intense, and where the brick is not likely to be disturbed so that only the upper side of the upper row of tubes needs to be covered. Hence tile forms completely surrounding the upper row of tubes are unnecessary and would detract from the heating surface of the boiler.

Engineers' Study Course

Trigonometry VII

LAST LESSON'S ANSWERS

26. If $\sin 45° = \frac{1}{2}\sqrt{2}$ the sine of 22 deg. 30 min., or half of 45° is (from equation 23, last lesson)

$$\sin 22° 30' = \sqrt{\tfrac{1}{2}(1 - \cos 45°)}$$

As the sine and cosine of 45° are the same

$$\sin 22° 30' = \sqrt{\tfrac{1}{2}(1 - \tfrac{1}{2}\sqrt{2})} = 0.3828$$

From equation 24

$$\cos 22° 30' = \sqrt{\tfrac{1}{2}(1 + \cos 45°)} = \sqrt{\tfrac{1}{2}(1 + \tfrac{1}{2}\sqrt{2})} = 0.9239$$

From equation 25

$$\tan 22° 30' = \sqrt{\frac{1 - \cos 45°}{1 + \cos 45°}} = \sqrt{\frac{1 - \frac{1}{2}\sqrt{2}}{1 + \frac{1}{2}\sqrt{2}}} = 0.4142$$

From equation 26

$$\cot 22° 30' = \sqrt{\frac{1 + \cos 45°}{1 - \cos 45°}} = \sqrt{\frac{1 + \frac{1}{2}\sqrt{2}}{1 - \frac{1}{2}\sqrt{2}}} = 2.4137$$

(Note that these values lie about midway between those given for the corresponding functions of 22° and 23° in the table in Lesson II.)

27. Required to find an expression for $\sin(A + B + C)$. Calling $A + B$ for the time being one angle, then, from equation 11,

$$\sin[(A + B) + C] = \sin(A + B)\cos C + \cos(A + B)\sin C$$

Also from equation 11,

$$\sin(A + B) = \sin A \cos B + \cos A \sin B$$

and from equation 13

$$\cos(A + B) = \cos A \cos B - \sin A \sin B$$

Then, substituting in the first equation,

$$\sin[(A + B) + C] = (\sin A \cos B + \cos A \sin B)\cos C + (\cos A \cos B - \sin A \sin B)\sin C$$

or

$$\sin(A + B + C) = \sin A \cos B \cos C + \cos A \sin B \cos C + \cos A \cos B \sin C - \sin A \sin B \sin C$$

28. From equation 5 (Lesson III)

$$\sec(A + B) = \frac{1}{\cos(A + B)}$$

and, from equation 13

$$\cos(A + B) = \cos A \cos B - \sin A \sin B$$

therefore

$$\sec(A + B) = \frac{1}{\cos A \cos B - \sin A \sin B}$$

This may be reduced to terms of the secant and cosecant if desired as

$$\sec(A + B) = \frac{\sec A \sec B \csc A \csc B}{\csc A \csc B - \sec A \sec B}$$

29. $\sin 3A$ is the same as $\sin(2A + A)$, then, from equation 11,

$$\sin(2A + A) = \sin 2A \cos A + \cos 2A \sin A$$

Substituting the values of $\sin 2A$ and $\cos 2A$ (equations 19 and 20)

$$\sin(2A + A) = 2 \sin A \cos A \cos A + (1 - 2 \sin^2 A)$$
$$\sin A = 2 \sin A \cos^2 A + \sin A - 2 \sin^3 A$$

From equation 1 (Lesson III).

$$\cos^2 A = 1 - \sin^2 A$$

then

$$\sin(2A + A) = 2 \sin A(1 - \sin^2 A) + \sin A - 2 \sin^3 A$$

which simplifies to the form

$$\sin 3A = 3 \sin A - 4 \sin^3 A$$

30. Given $\tan 30° = \frac{1}{\sqrt{3}}$.

From equation 21,

$$\tan 60° = \frac{2 \tan 30°}{1 - \tan^2 30°} = \frac{2 \times \frac{1}{\sqrt{3}}}{1 - \left(\frac{1}{\sqrt{3}}\right)^2} = \frac{\frac{2}{\sqrt{3}}}{1 - \frac{1}{3}}$$

$$= \frac{3}{\sqrt{3}} = \sqrt{3}$$

As $\tan 30° = \cot 60°$ (60° *and* 30° being complementary angles) $\cot 60° = \frac{1}{\sqrt{3}}$.

From equation 7 (Lesson III)

$$\sec^2 60° = 1 + 3 = 4$$

$$\sec 60° = \sqrt{4} = 2$$

From equation 5

$$2 = \frac{1}{\cos 60°} \qquad \cos 60° = \tfrac{1}{2}$$

From equation 2

$$\sqrt{3} = \frac{\sin 60°}{\frac{1}{2}} \qquad \sin 60° = \tfrac{1}{2}\sqrt{3}$$

SOLUTION OF RIGHT TRIANGLES

Recalling the definitions of the functions of an angle, as given in Lesson I, it begins to be evident how it may be true, as stated, also in the first lesson, that if any three of the six parts (three angles and three sides) of a triangle are known and at least one of them is a side, the shape and size of the triangle may be determined, at least insofar as this applies to right-angled triangles.

To recapitulate the relations between the sides and the trigonometrical functions of the oblique angles of a right triangle:

$$\text{sine} = \frac{\text{opposite side}}{\text{hypothenuse}} \qquad \text{cosecant} = \frac{\text{hypothenuse}}{\text{opposite side}}$$

$$\text{cosine} = \frac{\text{adjacent side}}{\text{hypothenuse}} \qquad \text{secant} = \frac{\text{hypothenuse}}{\text{adjacent side}}$$

$$\text{tangent} = \frac{\text{opposite side}}{\text{adjacent side}} \qquad \text{cotangent} = \frac{\text{adjacent side}}{\text{opposite side}}$$

Suppose it is given that the base and altitude of a right triangle are b and a, respectively. Here three parts are given, the right angle and two sides. The other side (the hypothenuse) can be found as the square root of the sum of the squares of the other two sides or

$$c = \sqrt{a^2 + b^2}$$

The sine of one oblique angle then will be $\frac{a}{c}$ and the sine of the other $\frac{b}{c}$. From the table (Lesson II) both of these angles may be found, or, one being found from the table, the second can be found by subtracting the first from 90° (the oblique angles of a right triangle being complements of each other, as previously explained).

Suppose the hypothenuse of a right triangle and one side are given as c and b respectively. Again, three parts are known. The third side will be

$$a = \sqrt{c^2 - b^2}$$

The sine of the angle opposite to the side b will be $\frac{b}{c}$ from which the angle B may be determined and the third angle (A) will be

$$90 - B = A$$

Suppose one oblique angle of a right triangle is given, A, and the adjacent side is b. Three parts are given, the third being the right angle. From the table *cos A* may be found, and the cosine being equal to the adjacent side divided by the hypothenuse, the latter can be found, as

$$c = \frac{b}{\cos A}$$

Two sides are now known, b and c; the third side a and also the angles may be found as before.

STUDY QUESTIONS

31. In a right triangle the sine of the acute angle at the base is ½ and the hypothenuse is 36 in. What are the lengths of the other sides and what is the sine of the other oblique angle?

32. The base and altitude of a right triangle are 20 and 32. Find the angles and the hypothenuse.

33. In a right triangle the hypothenuse is 235 and one angle is 43 deg. Find the other acute angle and the two other sides.

34. The angle of elevation to the top of a chimney is 47 deg. as measured from a point 180 ft. horizontally from its base. What is the height of the chimney?

35. When the 8-in. crank of a horizontal engine is vertical the piston is 1½ in. past midstroke. At this instant, what angle is the connecting-rod making with the guides?

⁂

Edinburgh to Have New Central Station—The electric-lighting committee of the Edinburgh Municipal Corporation, which has the monopoly of the production and distribution of electric current in Edinburgh, is preparing plans for a new generating station. The existing plant, which has been operated so successfully for many years that the committee has gradually reduced prices to 2¼c. per unit for manufacturing purposes (1⅜c. to large consumers) and 5¼c. per unit for domestic lighting (with discounts which bring it down to 4c.), will not economically produce enough current for the requirements of the near future. In arranging for another station, all new ideas, designs, and appliances will be considered by the committee, with the purpose of supplying electricity at the lowest possible figures.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

What is "the largest" anyhow? We said the new Equitable Building was to have the largest number of elevators (48) because we so read it in "Building Management." Now Charley Naylor pooh-poohs us and intimates the Equitable is a bungalow alongside the Marshall Field Co store, which has 64 passenger elevators, 14 freight, and 21 dummies and package hoists. And by way of good measure, he says the annex to Field's has 15 passenger, two freight and six dummies. Ring the bell if you want to go up!

⁂

However, some large things were done last year, as is pictured in this week's foreword. That young "1914" recorder is no great shakes for infantile beauty, but get that enthusiasm!

⁂

In a barefaced attempt to exploit our erudition last week, we said we knew two Latin quotations, and quoted one of them, "Caveat emptor" (Let the buyer beware). Then "Poor Old Bill" leaves his domiciliary elevation to dare us to tell the other one. No Trentonian can give us the dare, and get away with it—the other one is "Gesundheit"!

⁂

A Brooklynite has reached the tender age of 102 by indulging in "three good laughs an hour." We know where we could procure two good smiles an hour if we needed them, but three good laughs are hard to find. Possibly some reader may know where Brooklyn is, and help us out.

⁂

"Conservation of natural resources is," remarks the Buffalo "Express," "talking forever about water power and coal mines, and never using them." First thing you know, Mister "Express," somebody will make you eat them crool words.

⁂

"A mechanic was ordered to take care of a small gasoline pumping outfit during the night as we were short of water," relates an American engineer in Cuba. "About 12 o'clock the chief mechanic, while making his rounds, missed the sound of the exhaust. Upon investigation, he found that the connecting rod had worked loose and that piston and rod were reposing across the room and the engine a beautiful wreck. The boy was still asleep at his post."

⁂

Figures 2 ft. high are to take the place of street names on the Pittsburgh street cars. Don't know how this will work out, but what do New Yorkers know about street railways, anyhow? Two bells start the horses, and one stops them.

⁂

Owing to a severe shortage of water supply, a Kentucky electric-light company had to get its water by rail. You'd think that in the Blue Grass country water was running about loose, but this was boiler-feed water, not drinking.

⁂

A HAPPY NEW YEAR TO YOU

By B. Spills

We've said goodby to 1913 and howdy to 1914. Now let's be kind to the youngster; he's sturdy enough if we take the artist's conception of him in this week's foreword.

Big business enterprises are on the slate, the Federal and state governments are going to do things in our field, and others, and it's up to you and to me to sit tight, and look pleasant and hopeful.

If you read "Power's" editorial, "Progess in 1913," page 19, you must be startled by how much can be accomplished in one short year. My goodness gollies, old Pop Time sure can swing that grass-hook! Not so fast, Pop; we're missing some of the stations, and we'd like to stop off before our mileage runs out. (Pop's the only man who ever got away with the perpetual-motion idee.)

It's good to know, too, that the hearts of the big-wads have opened up the past year. For one thing, $550,000,000 are on tap for education and charity. We need all the education we can get, no matter who helps us to it. As for charity, we need that, too—in our hearts—for our fellows, our neighbors, and ourselves.

Here's for a happy new year!

Two Years' Experience with Co$_2$ Recorders

By Ernest O. Hickstein

SYNOPSIS—By stopping up all leaks in the settings and around doors, and by stimulating competition among the firemen, the average percentage of CO_2 was raised in nine months from 8 to 12.5 per cent.

*

It is rarely that one sees reports showing in detail just how boiler efficiencies have been increased, or by just what means low CO_2 percentages have been raised through the use of recorders. The writer has been in daily touch with one make of CO_2 recorder for two years past, the larger part of this time in a boiler plant where 20 recorders are in constant operation. The boiler house furnishes steam for power and industrial purposes for a large manufacturing plant on the New Jersey side of the Hudson River, and contains 20 water-tube boilers—14 Babcock & Wilcox and six Edgar—all connected with Green economizers. There are two large stacks, 250 ft. high. The boilers are hand fired, and dutch-oven furnaces extend 5 ft. in front of the boilers. A mixture of 90 per cent. No. 3 buckwheat and 10 per cent. soft coal is burned on a special small-hole dumping grate with forced draft. The maximum pressure in the ashpit is about 1¼ in. All the drums connect into one header. The boilers run day and night, usually at from 30 to 40 per cent. overload, and the demand for steam is regular. A CO_2 recorder unit and a recording thermometer are attached to each boiler.

The first month after the CO_2 recorders were installed, the average percentage of CO_2 was found to be around eight. By means of the methods to be recounted, this average was raised in eight months to 12.5 per cent. There has been little difficulty since, in keeping the average around that figure, but this seems to be about the limit under the conditions. The following tabulation gives the average for the plant during the eight months it took to raise the percentage up to a satisfactory figure and shows how gradual the improvement was:

	Per Cent.
1st month	7.78
2nd month	8.98
3rd month	9.26
4th month	9.88
5th month	10.24
6th month	10.59
7th month	10.73
8th month	11.65
9th month	12.46

How this was done can be told most directly by putting each step under one of three headings, which will be taken up in the following order:

1. Making the boiler settings tight.
2. Making sure that the recorder was getting a fair sample.
3. Improving on the methods of firing.

Making the Boiler Settings Tight

The boiler settings, when the recorders were put in, were in only fair condition. While some effort was made to prevent too much air leaking in, still if a match or candle were run along the brickwork, here and there, the flame would be sucked in. The black spots on the whitewashed brick, caused by little explosions in the furnace forcing soot out through the leaky settings, attracted attention primarily because it meant another coat of whitewash for the brickwork.

There had been no incentive to having the settings absolutely tight. No one knew just how much air leaked in and the Orsat remained in its corner for a year without being touched. But with the machines installed, things were different. The superintendent, on his trips through the boiler house, could not help seeing the CO_2 charts, which told him that things were not as well as they might be. Moreover, the recorders indicated whether conditions were improving; they supplied the incentive to the men in charge.

The brickwork of the settings, economizers, breechings and flues was overhauled, loose brick, wherever found, were replaced, and the boiler walls were well covered with asbestos cement. Care was taken that there was no leakage at the tube-blowing doors, or at the side, rear or firing doors. The tops of the boilers were covered, 1½ in. deep with cement over the brickwork. Of course, these are ordinary precautions, but two things done, however, were more uncommon, and deserve special mention.

As the boilers were often worked steadily for several months at a time, and at overload, cleaning the cinder pits by hand was arduous. Shortly before the recorders were installed, a hole about a foot square, had been drilled at the center of each of these pits, through to the cellar. The idea was that cinders carried into the second pass of the B. & W. boilers and falling into the cinder pits could be washed down into the cellar by playing a hose through the side doors. This idea worked very satisfactorily, except that such poor means were first used for keeping the holes air-tight, that considerable leakage resulted. When it became a question of getting high CO_2, however, a casting was inserted in each hole and cemented in place. These castings had grooves along the bottom to hold tight-fitting slides in place, and by this means all leakage through the holes was eliminated.

Leakage around the large front doors of a B. & W. boiler has a doubly bad effect, for in addition to diluting the hot flue gases with cold air, it strikes directly against the front header. These large heavy doors are hard to keep tight, so a simple but ingenious plan was adopted for preventing leakage. The air that leaks in through the front door passes either through the spaces between the headers, or up through the large opening just in front of the top of the headers; it was decided to block both these paths. Asbestos rope was forced into the openings between the headers with a calking tool. Also, a sheet-iron apron about 18 in. wide, and extending the width of the boilers was suspended just above the front doors, to seal the space above the header. Thereafter it was necessary only to keep the outer doors reasonably tight to prevent the air from cooling the front headers—the leakage into the boiler having been reduced to a negligible quantity.

Making Sure That the Recorder Was Getting a Fair Sample

Samples of the flue gas are taken by means of a ¾-in. pipe, inserted through the brickwork, directly in front of the breeching. This pipe is open at the end only. The recorders were installed under the supervision of a representative of the manufacturer, and at that time the ¾-in. pipes were only 3 ft. 6 in. long, probably because the alley between the boilers was only a little over 4 ft. wide. This permitted the pipes to extend only a little over 2 ft. inside the wall. The boilers are 16 ft. wide and the breeching 4 ft.; hence the sample was taken from a sort of dead pocket far to one side of the current of gas through the boiler into the breeching.

It was then ascertained that the recorder readings did not agree with the Orsat readings taken through a longer sampling tube extending halfway into the boiler. Also, the readings from the recorder with the short tube did not vary nearly so much with varying conditions of the fire as did the Orsat readings. Thereupon it was decided to use a sampling tube extending 8 ft. into the boiler. This was done and an immediate improvement in the charts resulted.

SAMPLE PAGE FROM FIREMEN'S RECORD BOOK

CO_2 Record

Two Weeks beginning Monday, May 12, 1913

Night Shift	Mon 12		Tues 13		Wed 14		Thu 15		Fri 16		Sat 17		Sun 18		Mon 19		Tue 20		Wed 21		Thu 22		Fri 23		Sat. 2A		Sun. 25	Average
											9		11		12		14											
560 Scullion	3	13.5	4	14	5	13.5	6	13	8	12.5	10	12.5	10	A	13	13	13	12.5	1e	12	3e	13	5e	12.5	6e	A		12.91
									9		11		12		14													
546 Cannon	4	14	5	14	6	13	7	12.5	10	12	10	12.5	13	×	13	12	1e	11.5	3e	12.5	5e	11	6e	13	2	13		12.58
							8		11		12		14															
564 Shultz	5	14	6	12.5	7	12.5	10	×	10	11.5	13	×	13	12	1e	12.5	3e	12	5e	12	6e	14	1	13	3	12.5		12.59
					8		11		12		14																	
550 Barnetzkay	6	12.5	7	12	10	×	10	11.5	13	12	13	11.5	1e	A	3e	×	5e	11	6e	A	1	A	2	12.5	4	×		11.86
			8		11		12		14																			
575 Jordan	7	13	10	10	10	11.5	13	12.5	13	12	1e	×	3e	11	5e	12.5	6e	×	1	×	2	12.5	3	13	5	13		12.10
	8		11		12		14																					
562 Zeman	10	12	10	12.5	13	12.5	13	13	1e	11.5	3e	×	5e	12.5	6e	13.5	1	12	2	12	3	12	4	13	6	12.5	12-hr. shutdown	12.42
554 Tiese	11		12		14																							
	10	13	13	14	13	12.5	1e	12	3e	12	5e	13.5	6e	13	1	13	2	13	3	12.5	4	13	5	13	7	13		12.88
553 Oberhaus	12		14																									
	13	×	13	13	1e	13.5	3e	13.5	5e	13	6e	14	1	×	2	13	3	13	4	13.5	5	13.5	6	13	8	12		13.18
548 Publiskie	14																								9			
	13	×	1e	×	3e	13	5e	12.5	6e	12.5	1	×	2	×	3	13.5	4	13	5	13.5	6	12	7	12.5	10	9		12.39
556 Muchinsky																							8		11			
	1e	12	3e	12	5e	13.5	6e	11	1	12	2	12.5	3	13	4	13	5	13	6	11.5	7	12	9	12	10	12.5		12.31
																					8		10		12			
572 Bakoonas	3e	11.5	5e	12.5	6e	13	1	12.5	2	12	3	12	4	12	5	13	6	11.5	7	12	9	11.5	9	12	13	×		12.13
																			8		10		12		14			
545 Contract	5e	13.5	6e	13	1	13	2	12.5	3	13	4	12.5	5	13.5	7	13	7	13	9	11.5	9	11	13	11.5	13	12		12.54
																	8		10		12		14					
547 Staffon	6e	14	1	12.5	2	13	3	12.5	4	13	5	13.5	7	13	8	12.5	9	11	9	12	13	11	13	12	1e	×		12.50
															9		10		12		14							
563 Kutakoski	1	11	2	13	3	13	4	12	5	14.5	7	12	8	11	10	×	10	A	13	10.5	13	11.5	1e	11.5	3e	×		12.00
													9		11		12		14									
565 Bellows	2	13.5	3	12	4	12.5	5	13.5	7	13	8	12.5	10	12	10	12.5	13	12	13	12.5	1e	12.5	3e	A	5e	13		12.63

Explanation: The first column under each date shows the boiler the man is firing; the second column, the CO_2 percentage for the fireman. "A" means that the regular fireman was not working, and a cross indicates that the recorder was not working well enough to get the correct average.

For example, Jordan, check number 575, on Monday night, May 12th, fired boiler No. 7 and averaged 13 per cent. On Tuesday night he had boiler No. 8 and half of No. 10, and obtained 10 per cent. CO_2 on boiler No. 10. The CO_2 average of No. 10, which is divided between two firemen, is ignored in keeping the firemen's record.

Improving the Methods of Firing

The boilers having been put in first-class shape, it was "up to" the firemen to produce good results. The firemen at the plant are practically all illiterate foreigners having no interest in their work beyond "putting in" the 12 hr. of their shift. Being without education, there was no hope of advancement, and with the shop unionized after a very recent strike, the firemen getting $2.75 for 12 hr. work and threatening to go out again for more money, it seemed like a hard problem to induce the firemen to get a good CO_2 record. There was no way of finding out readily how much coal a man shoveled, or how much water each boiler evaporated. This, of course, made it difficult to detect shirking, particularly at night, until the recorders were put in. Thereafter the charts showed who worked and who did not, but unwillingness on the part of the boss fireman to reprimand shirking firemen, and his disinclination to lay off a man except for a "better reason than just a poor CO_2 record," made matters just as bad as before.

There was no money to establish a sort of bonus system for the best CO_2 average, and there was no way of making the men do their best for fear of losing their jobs, so, as a last resort, and with but little hope of success, the attempt was made to create a feeling of rivalry between the firemen.

Each CO_2 chart was averaged separately for the day and night shift, and the result recorded under the fireman's name. The average for each fireman was taken at the end of each two weeks, when the shifts changed. A page of the firemen's record book is shown herewith. With the help of the information given underneath, this record is self-explanatory.

SAMPLE LIST, SHOWING FIREMEN'S CO_2 AVERAGES

Night Shift:

Two Weeks ending Sunday, May 25th, 1913

Good:		Fair:	
553 Oberhaus	13.18	562 Zeman	12.42
560 Scullion	12.91	548 Publiskie	12.39
554 Tiese	12.88	556 Muchinsky	12.31
565 Bellows	12.63	572 Bakoonas	12.13
564 Schultz	12.59	575 Jordan	12.10
546 Cannon	12.58	Poor:	
545 Contract	12.54	563 Kutakoski	12.00
547 Staffon	12.50	550 Barnetzkay	11.86

A list was then made and posted in the boiler room, showing how the firemen stood for the two weeks. The men were grouped under the headings "good," "fair" and "poor." A sample list is herewith shown, corresponding with the page of the record book.

From the very outset, the posting of this list created more interest than was hoped for. The men under the heading "poor" have to stand for a good deal of chaffing, and the leaders are usually pleased over their position. An idea of how much interest is taken in the list can be gained from the fact that frequently men on the night-shift report for work half an hour early, on the afternoon when the list is posted. Once the drawer containing the firemen's record book was broken open, probably by some fireman who could not restrain his curiosity any longer. Before the installation of the recorders, most of the firemen would shut off their blast the minute they thought they were not being watched, regardless of what the steam pressure might be at the time. After the lists were first put up, quite the reverse happened. It was necessary, then, to watch the firemen only to make sure that they did not keep on the blast, when the safety valve was blowing.

A most potent factor in keeping up the fireman's interest in his position on the list is the superintendent. He often looks over it, and has pointed out to him, the worst and best firemen. When the lists were first posted, several of the lazier firemen complained that the last man got \$2.75 for his day's work just as the first man. About this time, it was decided to run on one less boiler, and as talk of another strike was dying out—winter was drawing near—these men were laid off for a week or two. That one lesson was sufficient for the whole fire room. The only reward given now to the leaders on the list is preference for Sunday work, when there is a partial shutdown on that day.

They have also learned that a "hole" in the fire means low CO_2 and they are always on the lookout. They are careful to cover their fires evenly, at the back and sides of the grate as well as at the front, so that large quantities of air cannot be forced by the blast up along the bridgewall or side walls or through the spaces between the firing doors in the front. They know by experience just what blast in the ashpit is needed for the best results, and by means of a glass U-tube put on the boiler front to show pressure in the ashpit, they can hold the blast at the desired mark.

The average of the CO_2 charts is taken by inspection, this method being by far the quickest and giving very satisfactory results. Some of the firemen, in their desire to get a good chart, will not shut off their blast, even when the safety valve is popping. Because of this fact, it is necessary to consult the steam-pressure chart before averaging the CO_2. When the steam is blowing off, the firemen should not be given credit for very high CO_2, nor should the conscientious fireman, who shuts off the blast when the steam is high, be penalized for a low percentage at this time.

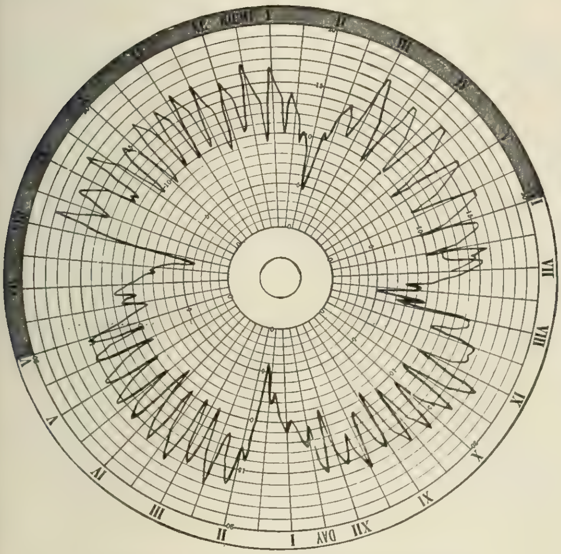


Fig. 1. CO_2 Average of 14 per Cent.

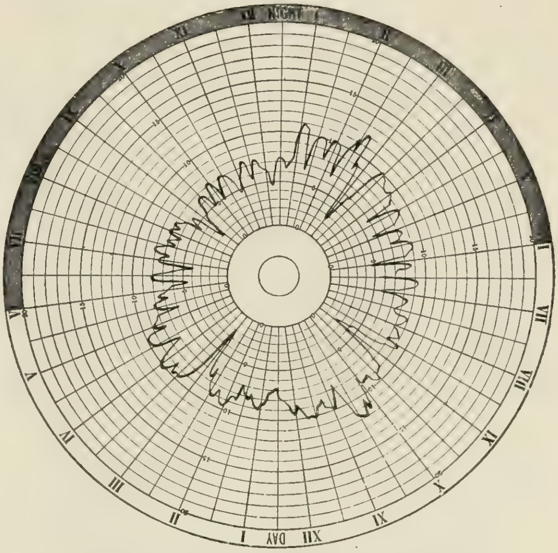


Fig. 2. CO_2 Average of 8 per Cent.

There are plants using CO_2 recorders, in which it is deemed best to conceal the record from the fireman who is making it. There is unquestionably a valid reason for this where a single recorder has to serve a number of boilers. By hiding the chart, the firemen cannot ascertain which of their number is being watched. Where there is a recorder for each boiler, however, much better results should be obtained by allowing the fireman to see the record he is making. If a fireman is anxious to make as good a chart as possible, he will watch the recorder as he covers his fire, cleans, etc. It will gradually be impressed on his mind that one method of doing this thing or that means a higher percentage of CO_2 than a second method, and slowly but surely, his whole system of firing will improve.

The firemen in the plant mentioned have found out for themselves that light firing at frequent intervals gives a higher CO_2 average than heavier firing at longer intervals.

Conclusion

It is the general impression that CO_2 recorders get out of order very easily and require considerable attention, an impression that is borne out by the experience of many engineers. The CO_2 recorder in a small plant is usually put in charge of the chief who is often the busiest man around the plant. He has his routine duties, subject to change in an emergency, but if the recorder is not working right, he will not call that an emergency, and may let it go for a day or a week. Consider how different it would be if the chief assigned one of his men to the instrument. A technical man is not needed to take care of it, although a certain amount of mechanical knowledge or instinct is very necessary. This man would be responsible to the chief for keeping the machine running, and would give attention to it at the proper time. This is unquestionably the only way in which a small plant can get its money's worth out of a recorder.

In a large plant, with a number of machines, there is usually one man specially engaged for the recorders. Whether the instruments pay will depend on this man; they make good if he does; they cannot, unless he does.

The occasional use of the Orsat apparatus to supplement the CO_2 record by a determination of oxygen and carbon monoxide is well nigh indispensable. Occasionally, when a recorder is showing an especially high CO_2 percentage, it is well to take an Orsat reading. The CO reading at this time might show the presence of sufficient CO to indicate excessive loss through incomplete combustion. Three-tenths of 1 per cent. of CO is a conservative maximum limit.

The efficiency for the first six months of the present year was slightly over 70 per cent. 4 per cent. higher than for the six months prior to the recorders' installation. A gain of 4 per cent., when the efficiency is 66 per cent. corresponds to a saving of 6.06 per cent. in the coal bill. This saving, based on an annual coal bill of \$250,000, represents over \$15,000 a year, or about \$41.50 saved every day in the year, an amount which will pay the wages of the firemen.

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Physical Properties of Fuel Oil

By J. J. McIntosh

SYNOPSIS—Weight, gravity and heat values and its use as a fuel compared with coal.

⁂

There are two kinds of petroleum fuel; that which has been worked over in a refinery, and that which is used in its crude or natural state. In the first state it is in the form of residue, the light distillates having been taken off. In this state but little variation will be observed in the properties of the oil, and it will be found to contain a small percentage of water. In its crude state, however, the oil is apt to show wide variations of gravity and impurities. If it is asphaltic, it will also contain notable amounts of sulphur, while the percentage of water is generally between 2 and 5 per cent.; though in some cases the water content may be as high as 10 per cent.

TABLE 1. PROPERTIES OF DIFFERENT OILS

Baumé Gravity	Specific Gravity	Weight Lb. per Gal	Weight Lb. per Bbl	B.t.u. per Lb.	B.t.u. per Bbl
10	1.0000	8.33	349.86	18,280	6,395,441
11	0.9929	8.27	347.34	18,340	6,370,216
12	0.9859	8.21	344.82	18,400	6,344,688
13	0.9790	8.16	342.72	18,460	6,326,611
14	0.9722	8.10	340.20	18,520	6,300,504
15	0.9655	8.04	337.68	18,580	6,274,094
16	0.9589	7.99	335.58	18,640	6,255,111
17	0.9523	7.93	333.06	18,700	6,227,622
18	0.9459	7.88	330.96	18,760	6,208,810
19	0.9395	7.83	328.86	18,820	6,189,145
20	0.9333	7.78	326.76	18,880	6,169,229
21	0.9271	7.72	324.24	18,940	6,141,106
22	0.9210	7.67	322.14	19,000	6,120,660
23	0.9150	7.62	320.04	19,060	6,199,962
24	0.9090	7.57	317.94	19,120	6,079,013
25	0.9032	7.53	316.26	19,180	6,065,867

TABLE 2. RESULTS OF TESTS ON BOILER BURNING FUEL OIL

Date of test	Mar. 11	Mar. 12	Mar. 13	Mar. 15	Mar. 15	Mar. 17	Mar. 18
Duration of test, hr.	7	7	7	5	2	7	5
Steam pressure, gage, lb.	185.5	185.5	187.1	186.6	185.5	186.2	186.5
Steam temperature, deg. F.	450.0	446.0	457.0	459.8	482.3	445.0	443.0
Superheat, deg. F.	68.0	64.0	72.0	84.0	107.1	63.0	61.1
Feed-water temperature, deg. F	85.5	86.2	86.6	83.0	82.3	83.0	80.3
Factor of evaporation	1.22	1.2174	1.222	1.230	1.243	1.220	1.222
Flue-gas temperature, deg. F	449.5	436.0	454.0	467.2	495.6	436.8	400.0
Draft in furnace, in.	0	0	0	0.010	0.050	0.020	0.013
Draft, top last pass., in.	0.034	0.010	0.074	0.128	0.250	0.010	0.030
Loss of draft through setting, in.	0.034	0.010	0.074	0.118	0.200		0.017
CO_2 in flue gas, per cent.	14.53	14.38	14.48	13.57	13.14	14.54	14.21
Total water evaporation f. & a. 212 deg., lb	113,581	94,781	118,649	111,744	48,230	96,476	46,350
Total water evaporation, actual, lb	93,099	77,855	97,095	90,849	38,802	79,079	37,930
Total oil fired, lb.	7021	5738	7506	7411	3179	6146	2826
B.t.u. per lb. of oil, as fired	18,986	18,986	18,986	18,986	18,986	18,986	18,986
Fuel-oil temperature, deg. F.	131	139	131	118	118	136	139
Boiler hp. developed	470	392	491	653	699	399.5	268.7
Boiler hp. per cent. of rating	118.5	99.0	124.0	165.0	176.0	101.0	68.0
Actual evaporation per lb. of oil, lb.	13.26	13.57	12.93	12.25	12.20	12.86	13.42
Equivalent evaporation f. & a. 212 deg. lb.	16.18	16.52	15.81	15.07	15.16	15.68	16.40
Effi. boiler and furnace, per cent.	82.5	84.2	80.6	76.8	77.1	79.7	83.5

The oils found in the mid-continent and Eastern fields contain a paraffin base, while those produced in the Gulf and Western fields contain an asphaltum base. Generally speaking, the asphaltic oils are distinguished from the paraffin base oils by their greater specific gravity and viscosity. The asphaltic oils also contain large proportions of tar, pitch and bitumen, and therefore have relatively more carbon than the oils with the paraffin bases.

The principal constituents of crude petroleum are hydrogen and carbon, combined with small amounts of sulphur, oxygen and nitrogen. Sulphur has a low heat value and is otherwise an undesirable property of the fuel, while nitrogen may be classed as an inert impurity. Carbon contains 14,500, hydrogen 62,000 and sulphur 3900 B.t.u. per lb. If fuel oils were made up wholly of hydrogen and carbon, there would be almost an exact relation between the gravity and the number of heat units per pound, but the presence of varying amounts of other substances prevents this constant relation. It is found that oils rich in hydrogen are of lighter gravity and contain more B.t.u. per pound than oils that are rich in carbon.

In Table 1 will be found the weights and heat values of different oils. These data have been gathered from various sources, and have proved to be correct for the majority of cases, but as was noted above, the heat values vary to a certain extent in oils of the same gravity.

In studying the table it may be noticed that the average heat value of the oil, per pound, increases as the gravity diminishes. This would indicate that economy would be best subserved by the purchase of light oils; but since oil is sold by volume, instead of by weight, a barrel of heavy oil contains more heat units than a barrel of light oil. Thus, for example, a barrel of oil whose gravity is 10 on the Baumé scale contains 226,212 more heat units than one whose gravity is 20 on the same scale. The following formulas will be found convenient for converting gravity values:

$$Specific\ gravity = \frac{140}{130 + B}$$

$$Baume\ gravity = \frac{140 - 130}{sp.gr.}$$

It is found in practice that 1 lb. of oil is equivalent to 1.6 lb. of the best coal. In numerous tests, the relative values of the two fuels have been given thus: 3.75 bbl. of oil is equal to one ton (2000 lb.) of coal; 1 lb. of oil is equal to 1.37 lb. of bituminous coal; 1 lb. of oil is equal to 1.67 lb. of anthracite. The evaporative values of the two fuels has often been given as in the ratio of 11.2 for coal to 15.8 for oil.

From test data in the writer's possession, taken from the same boiler under the same conditions, the evaporative value for run-of-mine Pocahontas coal was 11.77, while for California crude oil it was 16.20. In a test run on a 400-hp. water-tube boiler, equipped with a Hammel burner and backshot furnace, the results obtained are shown in Table 2. The boiler was installed in a power plant in Texas and the test was conducted by the regular plant force.

In comparing these two fuels there are several important factors that must be borne in mind. Their relative evaporative values cannot be based on their calorific values alone. For instance, while theoretically it can be shown that oil requires a greater air supply than coal, in practice it is found that coal, on account of the volatile matter, requires a much greater air supply than oil for complete combustion. The attendant difficulties in the combustion of coal in the furnace, due to its characteristics, is a factor that tends to reduce its evaporative power. On the other hand, the combustion of oil in the furnace is much simpler. The fire can be easily manipulated and a more perfect mixture of air and gases obtained, which tends to make the evaporative qualities of oil superior to those of coal.

* *

Size of Steam Pipes from Chart

By W. L. Durand

SYNOPSIS—For pressures from atmospheric to 200 lb. and capacities from 1 to 10,000 lb. of steam per min., the proper size of pipe may be read directly from a chart.

*

The most common method used in determining the size of steam pipes is to assume a velocity of 6000 ft. per min. for pipes carrying high-pressure steam, and 4000 ft. for pipes carrying low-pressure or exhaust steam. That this method does not give satisfactory results, except over a very limited range, may easily be seen if the drop in pressure at these velocities is computed for different sizes of pipe. The accompanying table is based on a length of pipe of 100 ft. and an initial pressure of 100 lb. at 6000 ft. per min.

Size of pipe, in.	1	1¼	1½	2	3	4	6	8	10
Loss in pressure, lb.	16	10	7.7	5	2.6	1.7	1	0.68	0.5

From the above, it may be seen that in small pipes the loss in friction is so great as to affect the economy of operation, while, on the other hand, for large pipes, the formula requires a pipe larger than is necessary. This would make the cost of installation excessive since the cost of pipe and fittings increases very rapidly with the size.

The factors which enter into any problem of this character are weight of steam, length of pipe, density of steam, drop in pressure and diameter of pipe. To obtain accurate results, it is necessary to take into account all the above factors and any formula used in this connection should contain all of them and not simply one or two. A good formula, taking into account all of the above fac-

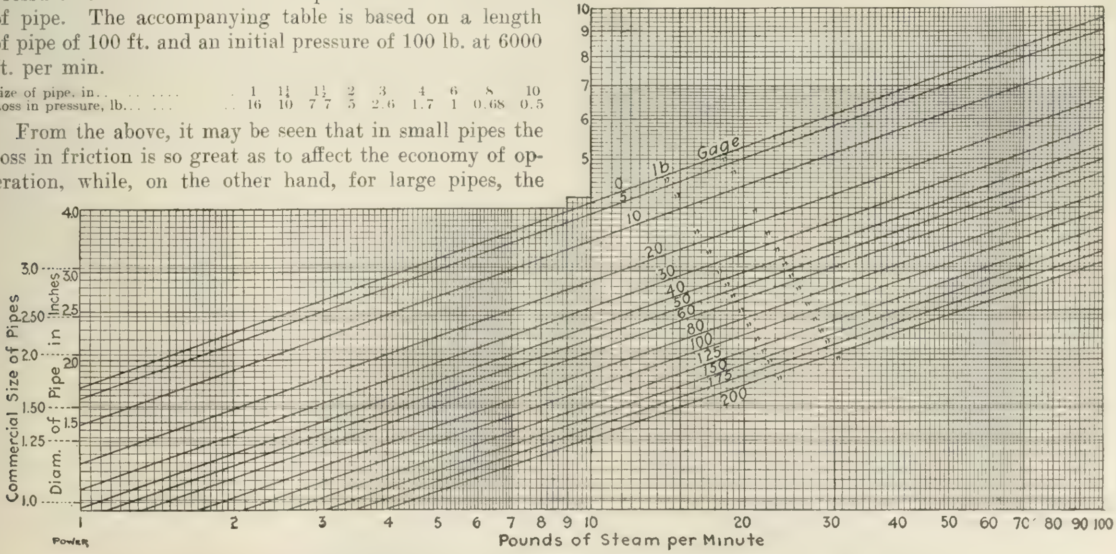

Fig. 1. Size of Pipe up to Capacity of 100 Lb. of Steam per Min.

tors, is the following, given by G. H. Babcock in "Steam."

$$W = 87\sqrt{\frac{w(p_1 - p_2)d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

W = Weight of steam flowing, lb. per min.;
L = Length of pipe, ft.;
d = Diameter of pipe, in.;
w = Mean density, lb. per cu.ft.;
p_1 = Initial pressure, lb. per sq.in.;
p_2 = Final pressure, lb. per sq.in.

The formula given by R. C. Carpenter and Unwin reduce to the same form, except that it has a factor of 87.5.

The reason that this formula is not in more general use is presumably due to the excessive amount of time required in solving it. The writer has been using for some time a set of curves based on this formula with satisfactory results and a great saving in time.

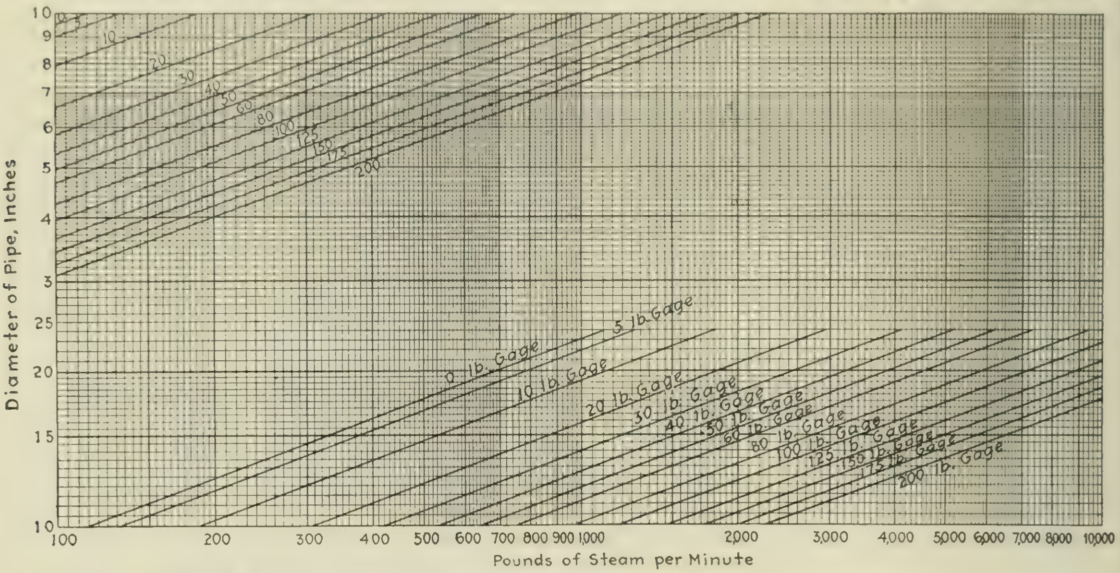

FIG. 2. SIZE OF PIPE FOR CAPACITIES OF 100 TO 10,000 LB. OF STEAM PER MIN.

As there are five variables in the formula and it is possible to plot only three of them without making the curves too complicated, the drop in pressure and length were taken as constants; the length at 100 ft. and the drop as 1 per cent. of the gage pressure, except at 5 lb. and atmospheric pressure, where it is taken as 1 oz. This gives a much better set of curves than if the drop is assumed as a constant at all pressures. If 1-lb. drop is taken, at 200 lb., the drop is too small and the result is a pipe larger than is necessary, with an increase in cost and radiation, while with 5-lb. pressure the loss is excessive.

These curves may be used for any other length or drop in pressure. For any desired length, divide the length expressed in feet by 100 and multiply the weight of steam per minute by the square root of this quotient, and then find the size of pipe for the weight thus found. This will be the proper size for this length of pipe.

For any other drop in pressure, divide 1 per cent. of the pressure by the drop desired and multiply the weight of steam by the square root of this quotient, and then proceed as above.

Take a case where it is desired to transmit 15 lb. of steam per min. at 100 lb. pressure, using the length and drop for which the curves are figured. From the curves a 2-in. pipe will be required. Suppose, however, the length is 250 ft. Proceeding as outlined above.

$$\frac{250}{100} = 2.5;\ \sqrt{2.5} = 1.58;\ 15 \times 1.58 = 23.7$$

From the curves a 2½-in. pipe will be required.

Take another case of 45 lb. of steam per min. at 10 lb. pressure requiring a 4-in. pipe, other factors being as in the problem above. Suppose, however, that it is permissible to have a pressure drop of 1 lb.

$$\frac{0.4}{1} = 0.4;\ \sqrt{0.4} = 0.63;\ 0.63 \times 45 = 28.3$$

This gives a 3½-in. pipe. If a different length and pressure drop is required proceed as above, using the drop per 100 ft.

To determine the length of pipe in inches equivalent to the resistance of one standard 90-deg. elbow, the following formula may be used:

$$L = 76\,d \div \left(1 + \frac{3.6}{d}\right)$$

For a globe valve

$$L = 114\,d \div \left(1 + \frac{3.6}{d}\right)$$

The resistance of gate valves need not be considered.

It might be well to call attention to the fact that, if extreme accuracy is required, the inside commercial diameter of the pipes should be used. These have been marked up to 3 in.

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Boiler Explosion near Oil City

By J. G. DENNINGTON

On the morning of Dec. 13, a 25-hp. locomotive boiler owned by C. P. Irwin and used with a drilling outfit about 12 miles from Oil City, Penn., exploded. No one was killed or injured and the damage was estimated at $300. It appears that the steam line to the engine was connected to the dome of the boiler by means of a tee. Between this tee and the boiler was a stop-cock and the safety valve was screwed into the top of the tee. Imagine such a connection for the safety valve.

Some repairs to the engine being necessary, the stop-cock was closed so as to shut off all steam from the engine, and when ready to fire up again the operator forgot to open it. The driller in going out to look over the boiler discovered that the gage showed nearly 200 lb. of steam, and remembering that he had forgotten to open the stop-cock started to run to his house near-by to warn his family so they would not be frightened when the boiler let go. The tool dresser followed and just as they got to the house the boiler exploded, scattering over a 10-acre field and breaking nearly all the glass in houses for a half mile around.

The New Massachusetts Institute of Technology Buildings

Plans for the new site of the Massachusetts Institute of Technology on the Charles River Basin, Cambridge, Mass., were recently made public by President R. C. Maclaurin.

Since the fiftieth anniversary of the Institute, some $7,350,000 have been raised for the purchase of the land and the new buildings.

The several sections are clustered about the library which has been made the central feature, with its Roman dome 200 ft. high, rising above a pillared portico. The central court in front of the library is open to the river front and expands near the esplanade to two minor courts. Shrubs, grass plots and fountains are to be used to relieve the severity of the clustered structures; trees are designed to accentuate the corners. The architecture is classical, with pilastered walls, permitting the recesses to be largely of glass. The long facades near the river will have pilasters two stories high and the third story forming the frieze. On buildings farther back a fourth or attic story is added above the entablature. Thus the group rises in height from front to rear. The detail treatment planned is very simple, beauty being sought in magnitude and proportion rather than by ornament. The departmental structures join one another so that it will be unnecessary to go outdoors in passing from one to another. By the use of interior courts, long and narrow wings result, receiving light from both sides.

In planning the position of the several departments, recourse was made to familiar circle diagrams showing the percentage distribution of time to various subjects in the several courses. For instance, half the time is devoted to mathematics and chemistry with the rest in general studies; for the remaining three years the predominant time factors are physics, and electrical and mechanical engineering. General studies and chemistry are housed close together in front of the library, while the electrical-engineering building is just back of it with mechanical-engineering laboratories on one side and physics on the other.

The technical departments converge on the library so far as possible, an arrangement which has been adopted to keep the special libraries of these departments close by the departmental buildings but yet under the care of the library force.

There will be about 2½ acres of drafting rooms, comprising the top floor of all departments except chemistry and general studies. The roofs over these rooms will be broken by standard saw-tooth skylights running across the narrow width of the longer buildings and giving northern exposure but hidden from view below by the high parapets.

The Pratt School of Naval Architecture and Marine Engineering is to occupy the most prominent land position. Only the general features of this structure have been developed, as actual construction must wait a year or two until other conditions have been fulfilled. It has been decided, however, that the school shall have its own entrance from the street; in the basement is to be a towing tank for ship models.

The largest auditorium, seating 2000, is placed within the interior court behind the Pratt School. Parallel with the latter is the mechanical-engineering department, with its heavy laboratories toward railroad tracks in the rear. Back here also is the power plant, of 4000-hp. capacity.

A gymnasium is planned to cost about $100,000, and to have a single floor of 15,000 sq.ft. area and a total floor area of 40,000 sq.ft. At the rear of the grounds is provided space for an athletic field with running tracks and grandstand.

Concerning the "Imperator"

It is but natural that much interest should be taken in such a large and elaborately equipped ship as the "Imperator." It is also to be expected that those interested should wonder why the largest of ocean-going liners should be taken out of service so soon after her maiden voyage. It may be that the daily press, in an effort to satisfy curiosity, has made erroneous statements.

Many rumors have been current. One had it that the boilers were inadequate to furnish steam to get the rated speed, and that oil-burning furnaces were to be used in the hope of remedying the trouble. Then came a rumor that the vessel was structurally weak in parts, followed by statements in the daily press that the builders of the vessel had been ordered by the Hamburg-American Co. to make good, at their own expense, the defects for which they were considered responsible by the owners of the vessel.

Now comes information to the effect that the builders of the "Imperator" guaranteed a speed of 23 knots per hour on 900 tons of coal per day, but that she uses 1150 tons. In consequence of this the turbines are being made over in some respects for the purpose of reducing the steam consumption. In addition to this the vessel is said to be top-heavy and to have been loaded with pig iron in the bottom. This increased the stability of the vessel, but it also increased her immersion. The effect of the pig iron and the vessel's own weight is that even when everything is taken from her that is practicable to remove, she draws 33 ft. 9 in. of water, and about 38 ft. when loaded. On account of this immersion the vessel cannot go behind the break-water at Plymouth, and, therefore, in bad weather it is extremely difficult to land passengers.

The American office of the Hamburg-American Co. states that the home office of the company denies the reports about the inadequate boiler capacity, oil-burning furnaces and the remodeling of the turbines. The reason given for the change in route which avoids Plymouth, is that it facilitates the travel of passengers to land those for Paris at Cherbourg before landing those for the British Isles at Southampton. From Southampton to London is about a two-hour ride while from Cherbourg to Paris takes four hours.

From the time of her maiden voyage until recently laid up, the "Imperator" has been in service seven months and has made seven round trips, carrying a total of about 30,000 passengers. The hot-water system has proved inadequate and changes were badly needed in the crew's quarters. For these two reasons, chiefly, the owners say the vessel was docked for alterations.

Refrigerating Engineers Meet at Dallas

On Dec. 11, 12 and 13 the Practical Refrigerating Engineers' Association held its fourth annual convention at Dallas, Tex., with headquarters at Hotel Adolphus. President Carl Nessler called the convention to order promptly at 10 o'clock, introducing M. S. Church, assistant city attorney, who in behalf of an absent mayor welcomed the association to the city. W. H. Lockett, of Dallas, responded.

After disposing of routine business there was still time at the morning session for the presentation of a paper on "Some Notes on Boiler Attachments," by R. T. Burwell. The paper was written from the standpoint of safety in operation and included some highly practical instruction on the safety valve, water gages and cocks, the steam gage, piping and fittings, the blowoff pipe, the feed pipe and fusible plugs. An extended discussion on feeding the boiler through the blowoff followed, with the consensus of opinion tending toward a safer method.

At the afternoon session J. F. Greenwood read an interesting paper on "Fuel Economy." In plain language the author told how to reduce the fuel bill and discussed the conditions favoring different kinds of fuel used in this part of the country, such as oil, Texas lignite and slack coal.

J. E. Phillips followed with a paper on "Efficiency," pointing out some of the unnecessary and avoidable losses common to the refrigerating plant. The third paper of the session was on "Ammonia" by J. C. Atwood. The properties of ammonia, methods of manufacture, quality of different makes, and incidentally an abbreviated outline of the development of the company with which the author is connected, were all included in the author's remarks.

J. R. O'Shanesy read a paper on "Precooling," briefly outlining the methods that had been employed since 1900 and describing in particular the plant at San Benito, which was ready for service early in 1911. For the benefit of those who could not attend, S. S. Van Der Vaart gave an interesting talk on the Third International Congress of Refrigeration held in Chicago late in September, and next in order was a paper by Joe McCrary entitled "Benefits I Have Derived by the Use of CO_2 Instruments." The author related conditions of the best equipped furnace in the plant when he first began to analyze the gases, and told how the instrument suggested improvements which resulted in a saving of 20 per cent. O. E. Morris talked on the "Relationship between Manager and Chief Engineer," emphasizing the importance of coöperation, mutual understanding and confidence in each other. A discussion on new methods and apparatus for re-icing cars ended the session.

DELEGATES TO THE FOURTH ANNUAL CONVENTION OF THE PRACTI

In the evening a smoker and Dutch lunch in the N. A. S. E. Hall proved to be a most enjoyable affair. The "get together and get acquainted" spirit predominated and Southern hospitality was in evidence.

On Friday morning a short account was given of the "Burhorn" cooling tower exhibited at the Third International Congress of Refrigeration, and the remarkable results obtained in a closed building with no movement of air. Brief discussion on this subject was followed by an extended controversy involving the policy and, as considered by some of the members, the life of the association.

A letter from H. H. Kelley, editor of the "Southern Engineer" and a member of the committee elected a year previous to provide a plan for the expansion of the association, was read at the meeting. Mr. Kelley outlined a plan calling for the formation of chapters, which should be controlled by a central or governing board. This board would be the national head of the association and composed of delegates selected by the several local bodies. The national body would hold annual meetings at various points as the one body does now. The money from dues would be spent for educational purposes, dispensed through the governing body and the education might comprise a thorough graded course in refrigerating engineering and subcourses in allied lines. The courses would be similar to those offered by the correspondence schools, but as the lessons would be studied jointly in the locals, the expense for postage between them and the national body would be small. The principal expense would lie in the preparation of the lesson papers. An employment bureau could also be formed to add to the incentive to join the association.

Mr. Van Der Vaart was called upon for an expression, and although he approved of Mr. Kelley's plan, he feared that the organization of chapters in the manner suggested would be impractical at the present time due to the expense attached to the work and very possibly the lack of organizers whose time would be available for the purpose. The same result might be accomplished in a shorter way by affiliating with the National Association of Stationary Engineers. From a talk with Mr. Raven, his association would apparently be willing to take the initiative in organizing chapters in different parts of the United States, these chapters to be affiliated with them, but at the same time members of this body, which will be as separate and distinct as it is today. A local on these lines had been already formed in Chicago.

Members entering into the discussion following were not favorably inclined toward the latter suggestion, as they were afraid of being absorbed by the larger body. It was finally decided to give the committee more time to confer with officials of the National Association of Stationary Engineers and work out a solution of the problem. To aid in the same direction vice-presidents were appointed in every state containing a member of the association.

At the afternoon session the convention listened to some trade talks on Brown's condenser paint, Garland rubber compound to repair leaks and Yale & Towne chain hoists. The time and place for holding the next convention were taken up, and Galveston was the choice of the majority. The following officers were elected. A. E. Page, president; D. L. Gilbert, Texas, first vice-president; Robert Jeffreys, Louisiana, second vice-president; Guy Conley, Arkansas, third vice-president; W. L. Storey, Oklahoma, fourth vice-president; J. H. Higginbotham, Mississippi, fifth vice-president; W. W. Hughes, Georgia, sixth vice-president; Sam Bayless, Alabama, seventh vice-president; W. A. Owen, Tennessee, eighth vice-president; F. H. Ladd, Florida, ninth vice-president; W. H. Beisley, South Carolina, tenth vice-president; Thyson Bernard, Virginia, eleventh vice-president; O. E. Morris, secretary-treasurer; R. G. Frazer, director; C. W. McGiboney, examiner.

Saturday was spent in visiting the North Fort Worth Stock yards upon the invitation of Armour & Co., the Texas Brewing Co., of Fort Worth and other plants of interest.

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Long Acre Co. Threatens Damage Suit

Following the recent court decision sustaining the franchise of the Long Acre Electric Light & Power Co., it is reported that this company intends bringing suit against the New York Edison Co., the A. N. Brady Estate and the Consolidated Gas Co. for alleged damages due to loss of profits during the period that its business has been tied up because of legal opposition from these interests.

Reviewing briefly the history of the case, the Long Acre Electric Light & Power Co. was organized in 1906 and steps were immediately taken to establish its right to use the conduits of the Consolidated Subway & Telegraph Co. for running its wires. This privilege was affirmed by the courts in 1907.

One year later the company applied to the Public Service Commission for permission to issue $50,000,000 in bonds and $10,000,000 in stock. This application was denied but later the commission voted to allow $2,000,000 in stock and $4,000,000 in bonds.

The New York Edison Co., after protesting to the commission, appealed from its decision, and when it lost in the Appellate Division, the case was carried to the Court of Appeals, which, on Dec. 19, sustained the action of the Public Service Commission.

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Recent Court Decisions

Digested by A. L. H. STREET

Right of Way for Oregon Electric Lines—The authority given under the statutes of Oregon to corporations to construct lines along streets and highways to convey electric power, etc., extends to corporations doing business in the state, though organized under the laws of another state. (Oregon Supreme Court, Northwestern Electric Co. vs. Zimmerman, 135 Pacific Reporter, 330.)

Abandonment of Water Rights—A water right is not abandoned by mere nonuse of it; abandonment will be declared only when shown to have been clearly intended by the possessor of the right. (Washington Supreme Court, Thorp vs. McBride, 135 Pacific Reporter, 228.)

Conveyance and Notice of Water Privileges—A deed, in ordinary form, to mill property, including "all and singular, the tenements, hereditaments and appurtenances thereto belonging or in any wise pertaining," carries with it water privileges appurtenant to the property, without special mention of those privileges. One purchasing land under a deed, which refers to a map on file in the county clerk's office, which map indicates the presence of a dam owned by a person owning land on the other side of the stream, is chargeable with constructive notice of the rights held by the dam owner. (New York Supreme Court, Monroe County Equity Term; Barnes vs. Martin, 143 New York Supplement, 792.)

EFRIGERATING ENGINEERS' ASSOCIATION AT DALLAS, TEX.

When City is Estopped to Declare Forfeiture of Power Franchise—A city which has granted a franchise to a company to produce and sell light and power, will not be permitted by the courts to dispute the validity of the franchise on the ground that, before it was granted, the company failed to procure the consent of abutting property owners to the placing of poles and stringing wires in the streets, as required by the laws of Illinois, where, acting on the faith of the franchise, the company has made large improvements and incurred much expense. "If the defendant had been wrongfully occupying the strets, the public authorities, in the exercise of proper diligence to prevent encroachment on the public right, might have compelled the cessation of such occupation. When they not only failed to do so, but took affirmative action with the apparent approval of every one interested, under which the situation was changed, extensive improvements were made, and large liabilities were incurred, the principles of equity require that the city should be estopped." (Illinois Supreme Court, People vs. Union Gas & Electric Co., 103 Northeastern Reporter 245).

NEW PUBLICATIONS

AN EXTENSION OF THE DEWEY DECIMAL SYSTEM OF CLASSIFICATION APPLIED TO THE ENGINEERING INDUSTRIES. By L. P. Breckenridge and G. A. Goodenough. Originally issued as Bulletin No. 9, in 1906, and still published by the Engineering Experiment Station, University of Illinois, Urbana, Ill. Price, 50c.

The filing and classification of engineering data has become a matter of much importance, and this bulletin was prepared for use as a guide in carrying out such work. The original edition of this bulletin was subject to the usual gratuitous distribution and the demand was such that a second edition was printed and distributed. The demand continuing, a revised edition, much extended as compared with the original eition, was printed in the fall of 1912. This edition was limited and is not subject to gratuitous distribution. It presents subdivisions of subjects in such detail as to constitute a complete classification for most engineering industries, even though they are highly specialized. The revision has been made in accordance with the 1911 edition of "Decimal Classification" by Melvil Dewey.

BOOKS RECEIVED

VACUUM-CLEANING SYSTEMS. By M. S. Cooley. Heating and Ventilating Magazine Co., New York. Cloth; 232 pages, 6¼x9½ in.; 104 illustrations; tables. Price, $3.

AMERICAN ELECTRICIANS' HANDBOOK. By Terrell Croft. McGraw-Hill Book Co., New York. Leather; 711 pages, 4¼x7 in.; illustrated; tables. Price, $3.

HANDBOOK FOR MACHINE DESIGNERS AND DRAFTSMEN. By Frederick A. Halsey. McGraw-Hill Book Co., New York. Cloth; 494 pages, 8½x11¼ in.; illustrated; tables. Price, $5.

COMPRESSED-AIR PRACTICE. By Frank Richards. McGraw-Hill Book Co., New York. Cloth; 326 pages, 6x9¼ in.; 96 illustrations; tables. Price, $3.

SHOP SKETCHING. By J. W. Woolley and R. B. Meredith. McGraw-Hill Book Co., New York. Cloth; 102 pages, 6x9¼ in.; 122 illustrations. Price, $1.

MECHANICAL REFRIGERATION. By H. J. Macintire. John Wiley & Sons, New York. Cloth; 346 pages, 5¾x9 in.; 121 illustrations; plates; tables. Price, $4.

QUESTIONS AND ANSWERS RELATING TO MODERN AUTOMOBILE DESIGN, CONSTRUCTION AND REPAIR. By Victor W. Page. The Norman W. Henley Publishing Co., New York. Cloth; 622 pages, 5x7½ in.; 329 illustrations; plates. Price, $1.50.

TRANSFORMER PRACTICE. By William T. Taylor. McGraw-Hill Book Co., New York. Second edition. Cloth; 278 pages, 6¼x9½ in.; 191 illustrations. Price, $2.50.

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Trade School Paper—"Occasional Suggestions" is the name of a little paper being published to present the principles underlying the methods of the Worcester Boys Trade School. The first issue, a small eight-page paper of a size convenient for the pocket, contains helpful suggestions for those who are interested in the training of mechanics.

SOCIETY NOTES

The Harlem Y. M. C. A., New York City, will, on Jan. 6, offer a complete course to those interested in heating and ventilation. It will consist of lectures, demonstrations of systems and appliances and discussion. The instructor is C. A. Fuller, a well known heating engineer. All information will be freely given by application to the Educational Department, Harlem Y. M. C. A., 5 West 125th St., New York City.

PERSONALS

L. E. Collins, formerly with Yeomans Bros., has associated himself with the Western Pump & Engineering Co., Chicago, and will specialize in house-service and bilge pumps.

A. R. Maujer, western editor of "Power," gave an illustrated lecture, Dec. 20, on chimneys at the joint meeting of the Milwaukee subordinate associations of the National Association of Stationary Engineers.

CIVIL SERVICE OPPORTUNITIES

Situation for Hoisting Engineer—The Chicago Civil Service Commission will hold an examination Jan. 8, for hoisting engineer, class Ea, grade II. The subjects of examination will be: Special subject, experience, arithmetic and report.

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Situations for Mechanical Draftsmen—The Chicago Civil Service Commission will hold an examination, Jan. 15, for the position of mechanical engineering draftsman, class B, grade II. Salary, $1500 to $1740. Subjects of examination: Special subject, mathematics, experience and report. Jan. 19 an examination will be held for mechanical draftsman, class B, grade I. Salary $1080 to $1320. Subjects of examination: Special subject, mathematics, experience and report.

⁂

Situation for Expert in Fire Prevention—The New York State Civil Service Commission will hold an examination for the foregoing position, Jan. 17, 1914. Salary, $3500. Candidates must have had at least ten year's experience in solving problems involved in direct and abutting fire hazards; the means and adequacy of exits from buildings; the interior arrangement and equipment of factories from the standpoint of safety of persons therein in case of fire or panic; the design, arrangement, installation and use of appliances for fire prevention. An appointee is desired between 30 and 60 years old. He must be a citizen of the United States and a resident of New York State. Application blanks should be sent for before Jan. 7, and returned by Jan. 9 to the secretary of the Civil Service Commission, Albany, N. Y.

⁂

Situation for Assistant Inspector of Gas—Public Service Commission, Second District. The New York State Civil Service Commission will hold an examination for the foregoing position Jan. 17, 1914. Salary, $1080 to $1200. The duties are to inspect and test gas for its purity and quality. Necessary traveling expenses will be paid in addition to the stated salary. Candidates must be college graduates in chemistry or have an equivalent education. Subjects of examination and relative weights: General and theoretical chemistry, quantitative analysis, photometry, calorimetry and manufacture of gas, 7; education, experience and special training, 3. Those desiring to compete should send for application blanks before Jan. 7, and return them by Jan. 9.

⁂

Situation for Chemical Engineer—The New York State Civil Service Commission will hold an examination for the foregoing position, Jan. 17, 1914. Salary, $3500. The duties require a knowledge of chemical engineering to determine the dangers to life and health arising from chemical manufacturing processes, and for the proper solution of similar problems. An appointee is desired between the ages of 30 and 60, who has completed a satisfactory course in chemical engineering, or other technical course, and who, in addition, has had practical experience in his profession or in work related to the duties of the position in question. Candidates must be citizens of the United States and residents of New York State. Application blanks should be sent for before Jan. 7 and returned before Jan. 9 to the Secretary of the Civil Service Commission, Albany, N. Y.

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Situation for Laboratory Assistant—The United States Civil Service Commission announces an examination for laboratory assistant, men only, on Jan. 21 and 22, 1914, to fill vacancies in this position in the Bureau of Standards, Department of Commerce, Washington, D. C., at salaries ranging from $900 to $1200 a year. The work is similar to that in the better class of industrial and scientific research laboratories. Competitors will be examined in general physics, French or German, practical questions on each optional subject chosen, education, training and experience. The following are the optional subjects: Electricity, electrical engineering, heat, mechanics, mechanical and civil engineering, optics, paper technology and textile technology. An educational training equivalent to graduation from a college or university of recognized standing is required. Applicants must be between 20 and 35 years old and citizens of the United States. Persons who desire this examination should at once apply for application Form 1312 to the United States Civil Service Commission, Washington, D. C.

⁂

Situation for Assistant Steam Engineer, State and County Hospitals, Departments and Institutions. The New York State Civil Service Commission will hold an examination for the foregoing position, Jan. 17, 1914. Usual salaries, $480 to $600 with maintenance when employed in institutions. Candidates, unless technical graduates, must have had two years' practical experience as machinist, boiler maker, steamfitter, oiler, fireman, engineer or electrician, including at least one year in the operation of stationary engines or electrical machinery. Technical graduates will be required to have had at least one year's satisfactory experience since graduation. Subjects of examination and relative weights: Practical and technical questions on the operation and repair of steam engines, boilers, steam-heating apparatus and electrical machinery, 6; experience, education and personal qualifications, 4. Those desiring to compete should send for application blanks before Jan. 7, and return them by Jan. 9, addressing the secretary of the Civil Service Commission, at Albany, N. Y. Candidates must be citizens of the United States and residents of New York State.

⁂

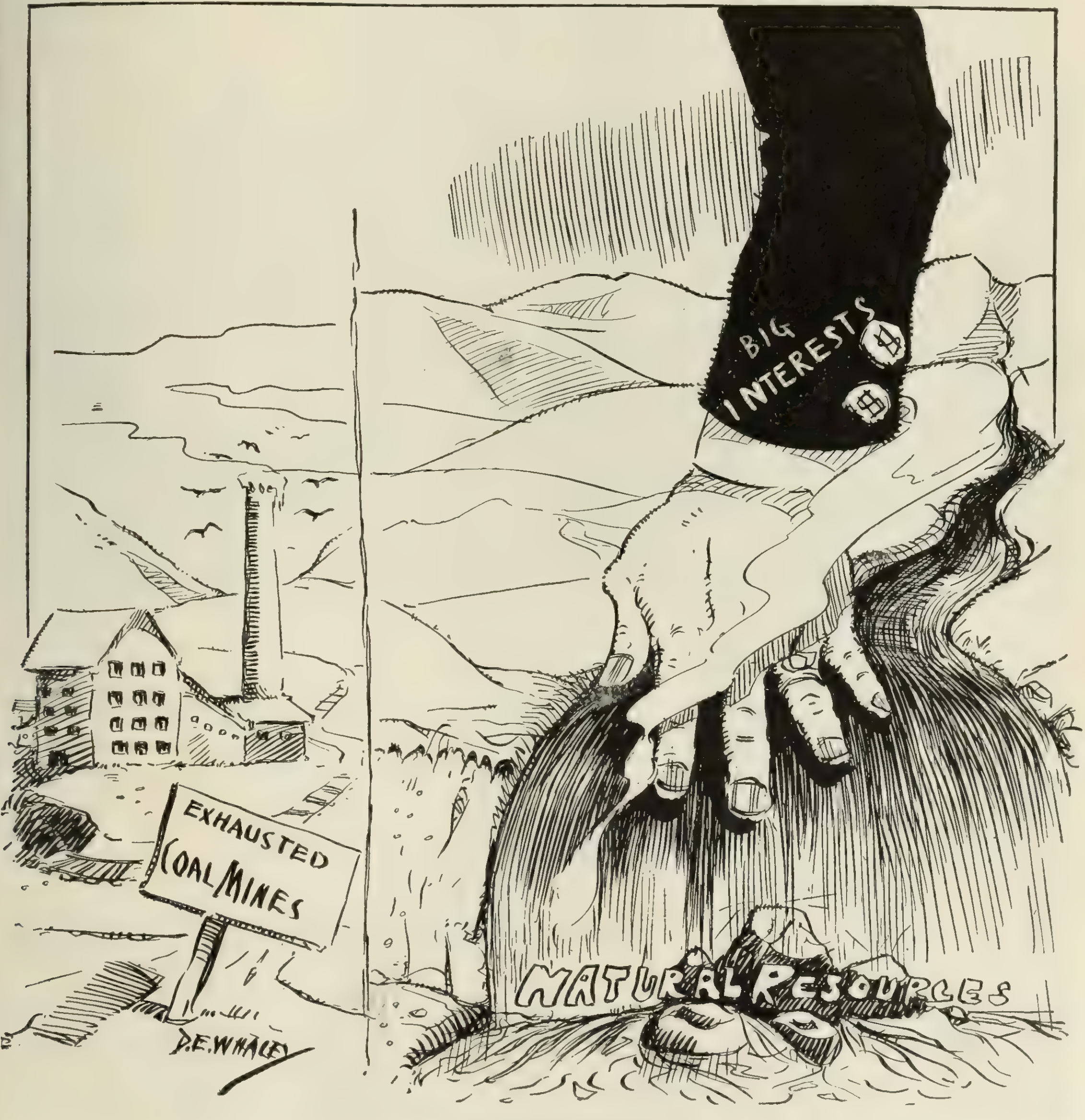
Situation for Assistant Electrical Engineer, state hospitals, departments and institutions. The New York State Civil Service Commission will hold an examination for the foregoing position Jan. 17, 1914. Usual salaries, $480 to $900 and maintenance. Candidates who are graduates in mechanical or electrical engineering must have had one year's practical experience in electrical work, or in the operation of stationary steam engines and electrical machinery. Other candidates must have had two years' practical experience as engineer or electrician, including at least one year in the operation of stationary engines or electrical machinery. Subjects of examination and relative weights: Practical and technical questions on electricity, electrical machinery and apparatus, steam engines, and steam and electric-power house practice, etc., 6; experience and education, 4. Those desiring to compete should send for application blanks before Jan. 7, and return them by Jan. 9, addressing the secretary of the Civil Service Commission at Albany, N. Y. Candidates must be citizens of the United States and residents of New York State.

⁂

Situation for Electrical Engineer (Assistant)—Public Service Commission, First District. The New York State Civil Service Commission will hold an examination for the foregoing position Jan. 17, 1914. Salary, $1501 to $2100. Appointees to this position will have to handle considerable work in connection with theoretical computations on the design of electric railroad equipment, and should be conversant with and experienced in the design, selection, installation and inspection of electric railroad motors, signals, switching apparatus, etc. Applicants must have had at least seven years' engineering experience in electric railroad work preferably with rapid transit or heavy electric traction lines. Graduation in engineering from a school of the highest grade will be accepted as equivalent to four years' experience. Subjects of examination and relative weights: Written examination, 2; experience, training and personal qualifications, 3. In rating the last mentioned subject an oral examination will be held. Those desiring to compete should send for application blanks before Jan. 7, and return them by Jan. 9, addressing the secretary of the Civil Service Commission of Albany, N. Y. Candidates must be citizens of the United States.

POWER

Vol. 39 NEW YORK, JANUARY 13, 1914 No. 2

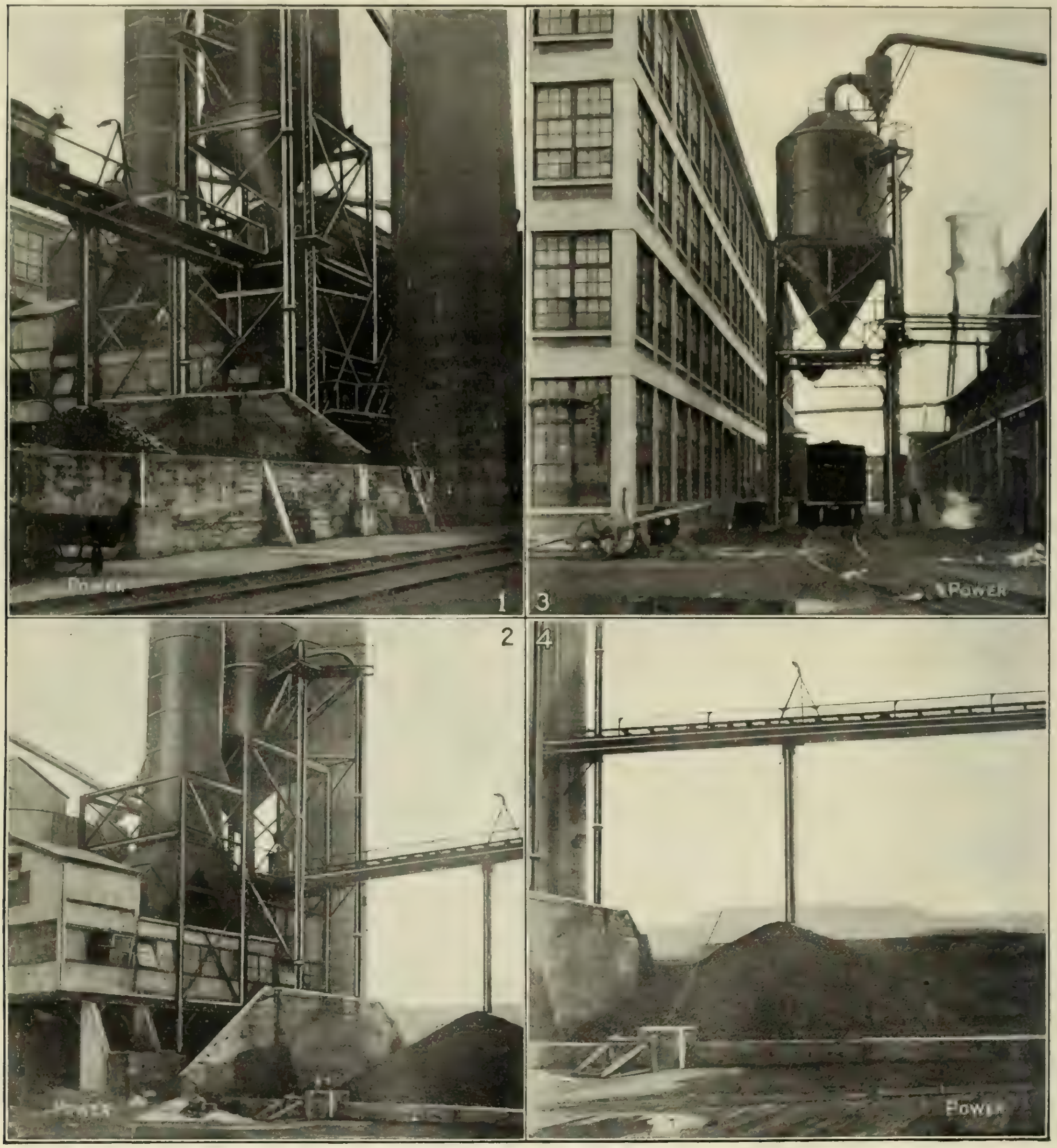


A PROSPECT

Coal and Ash Handling at Pierce-Arrow Plant

By Charles H. Bromley

SYNOPSIS—The plant uses 28,000 tons of coal a year, which averages 12 per cent. ash; all coal and ashes are handled by suction. Coal in an outside storage bin is sucked from beneath and elevated to a 150-ton tank from which it is dropped into an electric car and conveyed to the bunker, and finally discharged to the stokers. Ashes are drawn from the ashpits through 8-in. pipes to a tank of 90-ton capacity from which they are dropped directly into cars. Some operating troubles of the system are described.



Views of Coal- and Ash-Handling Equipment, Pierce-Arrow Motor Car Co.

The handling of ashes by suction is not new nor is it a rare practice, but the handling of coal and ashes by this system, and on a large scale is uncommon. At the plant of the Pierce-Arrow Motor Car Co., Buffalo, N. Y., 28,000 tons of coal averaging 12 per cent. ash is consumed annually. All coal and ashes are handled by application and modification of the Darley system to suit the conditions of location, storage, etc. At present nut coal is being used and this is handled as easily as slack.

Principal Parts of the Equipment

Essentially the system consists of a turbine-driven, (65-hp.) exhauster, which exhausts the air from large pipe lines leading from hoppers, for coal and ashes respectively, to elevated steel tanks. The coal tank, Figs. 1 and 2, is of 150-ton capacity and the ash tank, Fig. 3 of 90-ton capacity. The conveyor pipes, 10-in. for coal and 8-in. for ashes, carry about a 3-in. vacuum, while the system is operating. The ash tank is provided with a dust collector above the main tank. In Fig. 8 is a plan view of the collector showing how the dust is whirled and thrown outside the baffles to settle, while the air passes up through the center of the collector.

The coal is dropped from the tank into an electric car which carries it to the 75-ton bunkers over the boilers or to outside ground storage, Fig. 4, if the bunkers are full. From the bunker the coal is dropped directly to the stokers through the chutes.

Coal Enters Conveyor Pipe at High Velocity

Ordinarily the coal is dropped directly from the car into a feeder hopper in the conveyor pipe, but at the Pierce-Arrow plant short belt conveyors are provided to convey the coal at rather high velocity into the open end of the conveyor pipe, which is the most inefficient part of the system, owing to the inertia of the coal and eddy currents there. It is claimed that much more coal can be handled in this way than where it enters the feeder hoppers at a low velocity. Notice in Fig. 5 that there are two belt conveyors, one to take coal from the track hopper to the second belt which discharges it into the conveyor pipe. Originally these belt conveyors were not used.

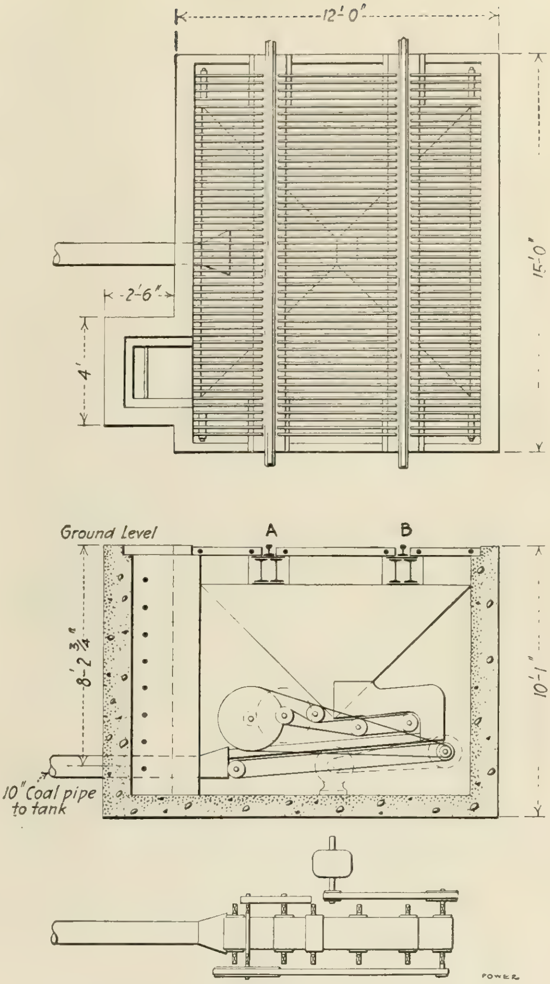


Fig. 5. Track Hopper Screen and Belt Conveyors

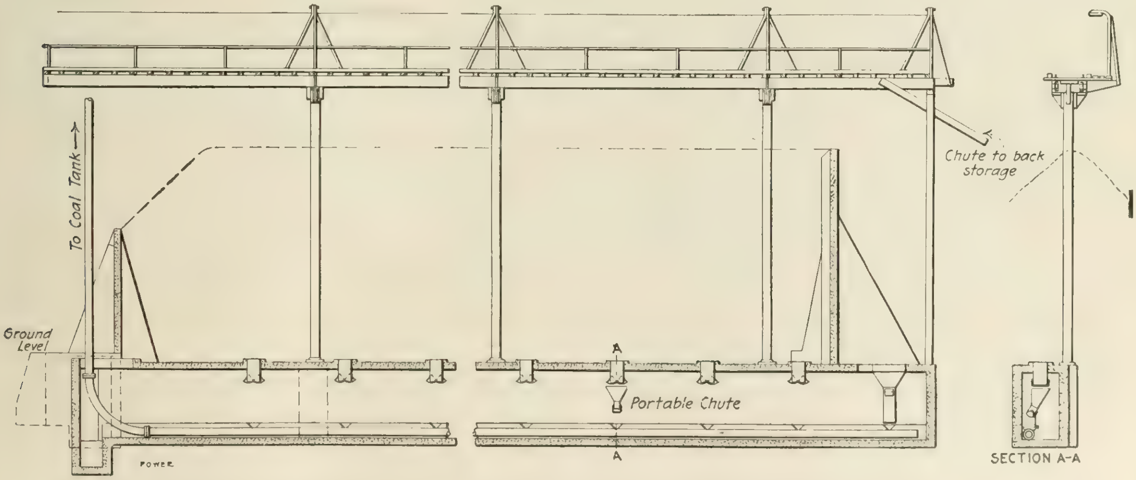


Fig. 6. Elevation of Ground Storage Bin, Showing Concrete Tunnel, Conveyor Pipe and Chute

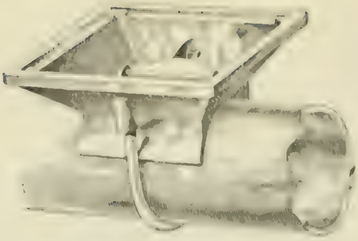


Fig. 7. Detachable Hopper

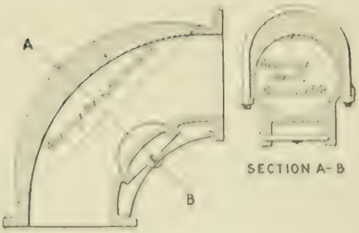


Fig. 9. Removable Back Elbow

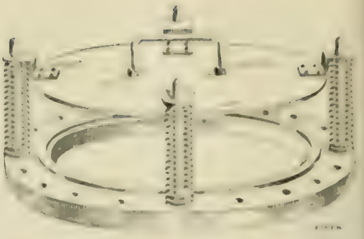


Fig. 11. Pressure Relief Cover for Ash Tank

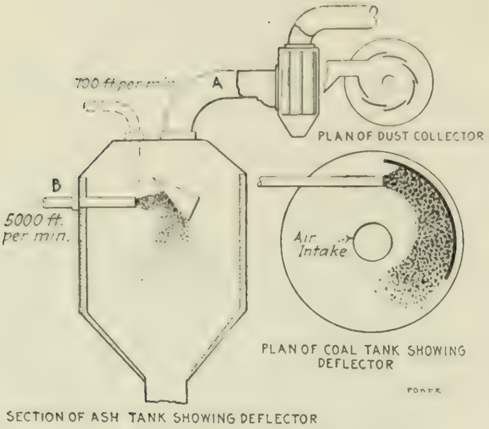

700 ft per min.
A
PLAN OF DUST COLLECTOR
B
5000 ft. per min.
Air Intake
PLAN OF COAL TANK SHOWING DEFLECTOR
SECTION OF ASH TANK SHOWING DEFLECTOR
POWER

Fig. 8. Dust Collector and Ash and Coal Deflectors

Handling the Storage Coal

The storage part of the system and the manner of handling the coal are rather interesting. As shown in Fig. 6, beneath the ground storage area is a concrete tunnel containing a 10-in. pipe leading to the coal tank and having detachable hoppers, Fig. 7, which are nearly in a center line drawn longitudinally through the coal pile above, and below openings in the floor of the storage bin. As the opening in the bin floor is not quite in line with the feeder hoppers in the 10-in. pipe, a portable hopper chute is provided in the tunnel to guide coal from above into the hoppers from which it is conveyed by suction to the coal tank. The floor of this tunnel has a slight slope to drain off what little water may get in.

The capacity of the ground storage area connected with the 10-in. suction pipe is 2000 tons, but another storage area of 2200 tons capacity not connected with the suction system is provided for emergencies. Not long ago the coal in storage took fire and it is interesting to know that the hot coal was sucked into the tank without causing any trouble.

Some readers may wonder why the coal or ashes coming into the tank are not carried over into the air duct and then to the blower, causing damage. The following explains this:

The air duct *A*, Fig. 8, is of much larger diameter than the ash pipe *B*. By connecting the larger pipe to the blower, the air velocity in the pipe *A* will be about 700 ft. per min. and that in the pipe *B*, about 5000 ft. per min. The coal or ash is too heavy to be carried up into

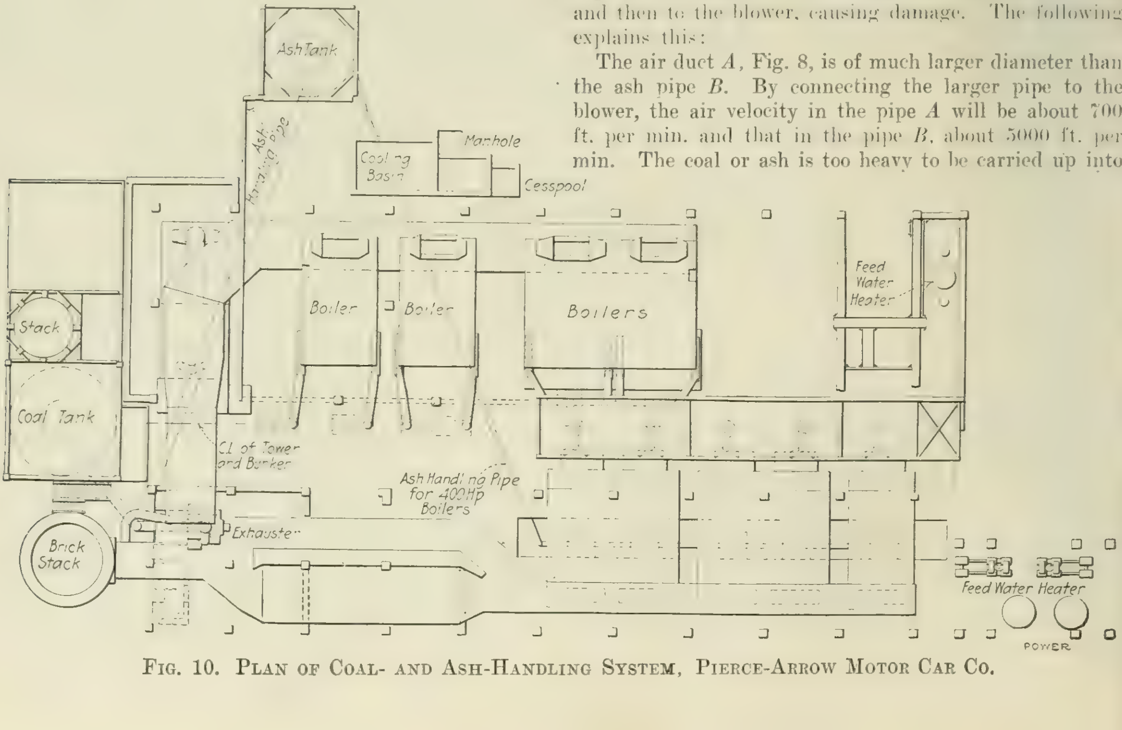


Fig. 10. Plan of Coal- and Ash-Handling System, Pierce-Arrow Motor Car Co.

the air duct when the air velocity is so low, even when it enters the tank tangentially as it does in this installation. Often the coal and ash pipes come into the tank from above, as shown by the dotted lines.

Provision for Wear of Conveyor Pipes

The wear on the elbows or bends in the conveyor pipes, whether for coal or ash, is considerable and so called removable wear-back elbows, Fig. 9, are used in nearly every installation. At the Pierce Arrow plant, these elbows were discarded for long sweep bends of special make so as to obtain a thickness of 2⅜ in. at the back. It was found that much more coal and ashes could be handled in a given time by the use of the bends, owing to less pipe friction. To prevent wear at the sides of the tanks, a concrete lining is often used.

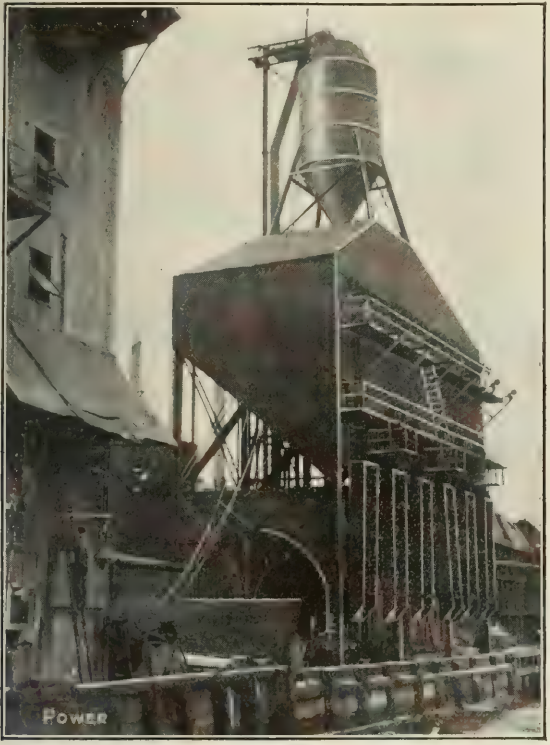


Fig. 12. Ash-Storage Bin on Water Front

There are two rows of boilers, five in each row, and originally the ash ducts under each row connected into a Y-fitting from which one pipe continued on to the tank. The Y and single pipe near it wore so rapidly that it became necessary to put in two separate pipe lines, one from each row of boilers direct to the ash tank, as shown in the plan of the system, Fig. 10, and since then no trouble has been experienced.

Explosions in Ash Tanks

When ashes are handled by this system, explosions sometimes occur, owing to an explosive mixture being formed in the tank by gases from the hot ashes mixing with air, a live coal or spark igniting the mixture. To provide against damage by such explosions, a relief cover shown in Fig. 11, is used on the top of the tank. The cover is free to be blown entirely off the guides, and springs are used to hold it off its seat when the tank is not in operation. One such explosion has occurred at the Pierce Arrow plant but no damage was done. A water line connected into the ash pipe near the tank is used to wet and cool the ashes. It is when this water line becomes plugged, frozen, drained or the valve closed that an explosion is likely to occur.

To prevent the moist ashes in the tank from freezing and binding together a ½-in. steam line is connected into the ash outlet of the tank.

At the Pierce Arrow plant, the engineers have tried to handle soot from the boilers with the system, but the water used to keep the soot moist enough to prevent it floating promiscuously throughout the system makes it form a putty-like mass that is so difficult to handle that the system is of no advantage over hand and shovel methods. In some plants soot is handled successfully, but where the soot is fine and powdery instead of granular it will plug the line after being wet. This could undoubtedly be overcome by admitting the water at, say, 2 ft. from the open end of the pipe in the tank, and by dropping the pipe vertically into the tank so that the weight of the wet soot would cause it to drop out of the pipe by its own weight.

As previously stated, the ash intake hoppers are usually at the front of the boilers, so to handle soot by the system a long heavy rubber hose with an intake nozzle like those used in vacuum cleaner systems, connects the soot chambers with the suction pipe.

Fig. 12 shows a type of storage bin used with an ash tank. This photograph was not taken at the Pierce Arrow plant but it is deemed of sufficient interest to warrant reproduction. From the bin the ashes are loaded into boats.

The system at the Pierce Arrow plant was installed by the Guarantee Construction Co., 140 Cedar St., New York City.

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Fulton-Tosi Oil Engines

Perhaps the latest entrant to the growing class of builders of Diesel-type engines in America is the Fulton Iron Works, St. Louis, Mo., which is building a line of oil engines after the general design of Franco Tosi, Legnano, Italy, a builder of poppet-valve steam engines, steam turbines and gas and oil engines. A side view (Fig. 1) and a perspective (Fig. 2) of a 150-hp. four-stroke-cycle vertical unit on the testing floor of the Fulton Iron Works are given herewith; the general design is shown in Fig. 3.

Following the general European practice the engine is built with an A-type frame; all the valves, each in a separate cage, are grouped vertically in the cylinder head; the camshaft is situated on a level with the tops of the cylinders, and the air compressor is directly connected. The camshaft is driven from the main shaft by means of the vertical shaft *B*, Fig. 3, and two pairs of helical gears. The governor which controls the delivery of the fuel pump is mounted on this vertical shaft at *C*.

The fuel pump, located at *A*, Fig. 3, and shown in detail in Fig. 4, is of a special patent design developed by H. R. Setz, chief engineer for the Fulton Iron Works.

The principle of this pump is shown in Fig. 5, although the construction is not identically the same as that in Fig. 4. Oil enters the pump through the suction valve *D*, Fig. 5, and is forced out by the plunger *E*, through the discharge valve *F*. As the stroke of the plunger is always constant its displacement must be likewise. Consequently, the quantity of oil pumped at each stroke is varied by varying the clearance volume of the pump chamber *G*. This is done by means of the vanadium-steel diaphragm *H* behind which are two spring-steel disks for reinforcing. The play of the diaphragm is limited by the plunger *I* whose position is controlled by the wedge *J* connected with the governor *K* in the manner shown. When the engine speeds up the governor rises, thereby partly withdrawing the wedge *J* and allowing the diaphragm greater play. The in-stroke of the pump plunger, then, instead of forcing the full measure of oil out at the discharge valve against the high back pressure encountered, forces out only the required fraction, while the bulging of the diaphragm takes care of the balance of the displacement. On the out-stroke the diaphragm returns to the normal position, thereby preventing admission of fuel in excess of that required. In the pump as actually constructed there are two diaphragms instead of one and these are at the sides of, instead of facing, the pump plunger.

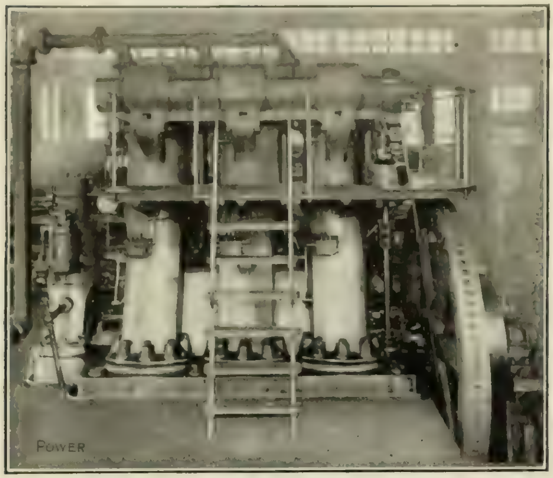

FIG. 1. 150-HP., THREE-CYLINDER, FOUR-STROKE-CYCLE FULTON-TOSI OIL ENGINE ON TESTING FLOOR

The fuel-injection valve of each cylinder is placed in a vertical position and in the center of the cylinder head, thereby making it possible to concentrate the bulk of air necessary to sustain combustion uniformly around the injection nozzle. A perfectly symmetrical and cylindrical combustion chamber is thus obtained which is conducive to maximum efficiency and insures easy control of the stresses to which the cylinder head is subjected. The mechanical clearance between the piston top in its highest position and the cylinder head is over 1 in., thus positively preventing contact between the piston and the cylinder head.

The principal parts of the fuel-injection valve are the atomizer, which consists of a series of perforated disks, mounted on the needle-valve guide, a grooved cone below these disks and the injection nozzle. The fuel oil is deposited on these disks by the pump while the needle valve is closed. This gives the oil time to distribute itself in a thin uniform layer over the whole surface of the disks so that when the needle valve opens the oil is swept from this large surface into the cylinder by the injection air.

The air and exhaust valves, which open inwardly, are each actuated by a single lever, the outer end of which rides on top of its cam. The fuel injection valve, however, opens outwardly, and, to bring the lever contact on top of the cam in this case, as well as in the other two, a second small lever is employed. This has as its fulcrum a pin in the bonnet of the valve itself set eccentrically and fitted with a handle and latch, so that the small lever may be shifted to change the lead of the valve and the duration of opening at will.

Accessibility is another feature of the valve and, for that matter, of the whole engine. By taking off the spring case at the top, the fuel needle may be withdrawn without disturbing the valve setting and the atomizer parts are made accessible simply by removing two nuts.

Two of the three cylinders are fitted with valves for starting on compressed air and these, themselves, are operated by air, instead of mechanically. This arrangement offers the advantage of doing away with one cam and lever, which is important because of the increased accessibility it makes possible. With only three cam-and-lever sets to the cylinder, the levers for the admission and exhaust valves can be pivoted on the ends of a pin, while the larger of the levers for the fuel valve is mounted at the middle, the pin being supported at either side of the middle lever. Thus, the exhaust- or admission-valve lever can be removed simply by taking out a tap bolt from the end of the pin.

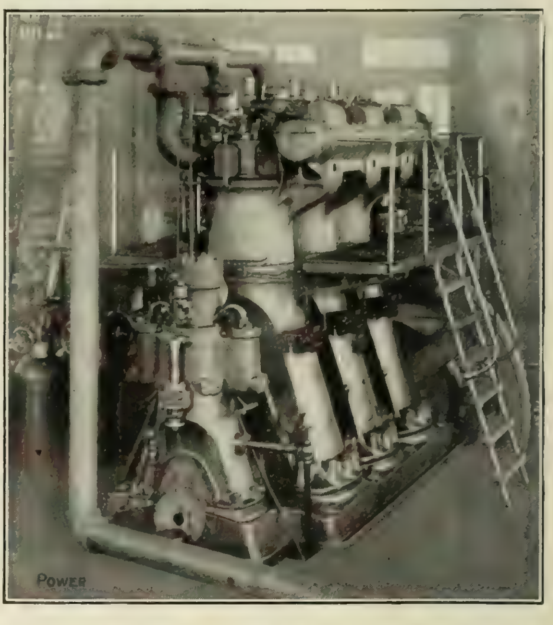

FIG. 2. ANOTHER VIEW OF THE FULTON-TOSI ENGINE

With air-operated starting valves the control is concentrated at one point so that the process of starting is reduced to a simple operation. By means of a rotary distributor, which is thrown out of operation after the engine is started, high-pressure air is admitted to the top of a piston mounted on the stem of the balanced starting valve. This raises the starting valve and permits the starting air to enter the cylinder during about 45 per cent. of the downward stroke of the piston, then the rotary distributor establishes a connection from the top of the starting valve to the atmosphere, which brings the valve back to its seat.

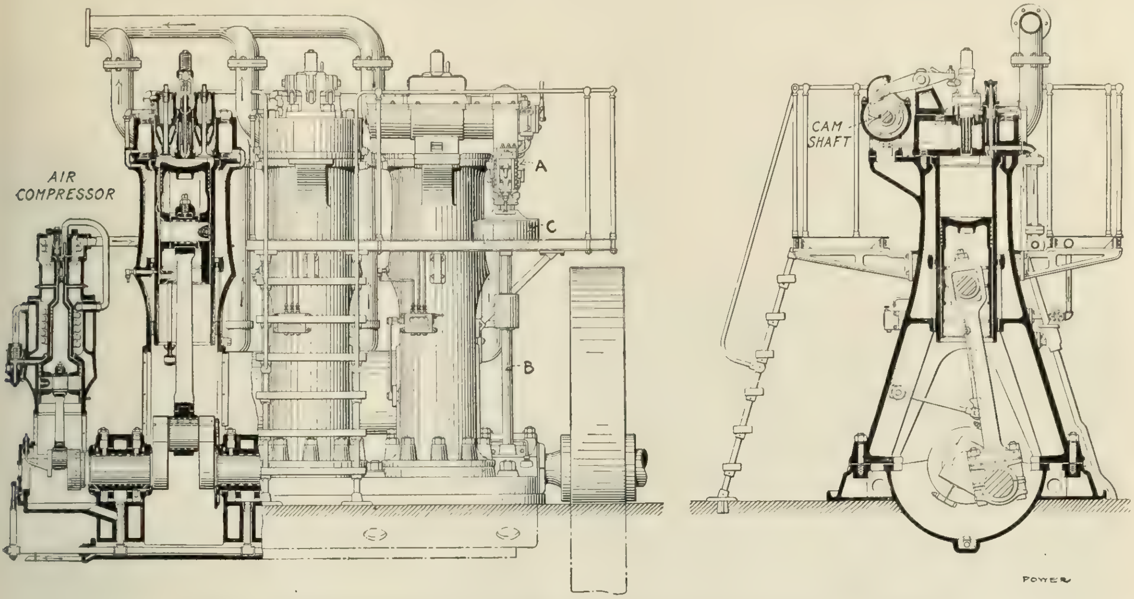

Fig. 3. Elevations, Partly in Section, of the Fulton-Tosi Oil Engine

The cylinder design takes the form of a heavy liner, the space between which and the outer casting comprises the water jacket. The admission valves are piped to the inclosed spaces of the crank cases so that the air drawn in may be somewhat higher in temperature than that outside and the crank and rods may enjoy the benefit of resulting ventilation. On the smaller sizes of engines all the main bearings are lubricated by means of oil rings, while the crankpins receive oil from a centrifugal ring, as customary on gas engines. On the larger engines the main bearings as well as the crank- and piston pins are lubricated by a rotary pressure pump. A separate sight-feed oil pump is provided for each piston which forces the oil into the cylinder at from four to eight points as the piston approaches the lower dead center.

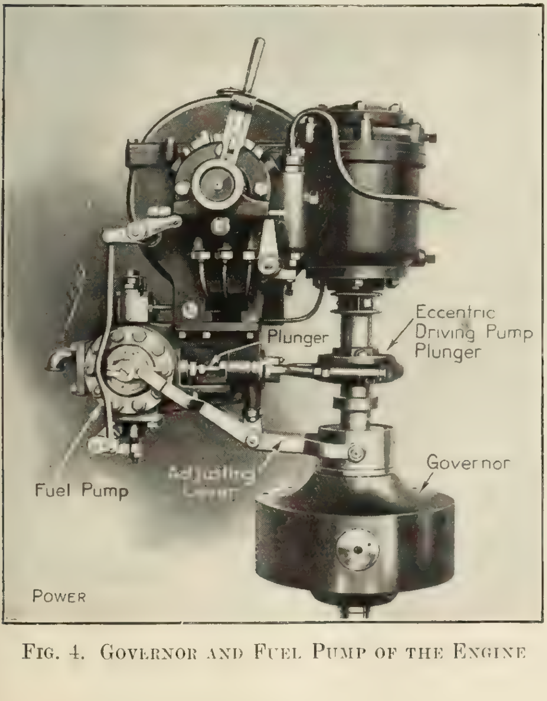

Fig. 4. Governor and Fuel Pump of the Engine

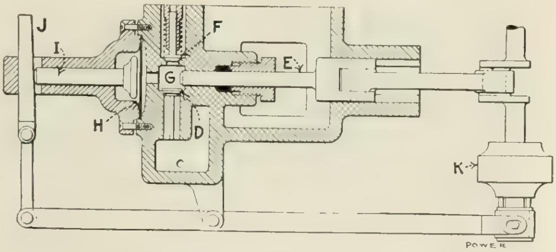

Fig. 5. Showing Principle of Fuel Pump

Conforming with the best European practice the three-stage injection air compressor forms an integral part of the engine. A cooler, arranged after each stage, is built into the water space of the compressor frame, thus making it a compact self-contained unit. The quantity of the air delivered by the compressor can be varied somewhat by throttling at the low-pressure inlet, thus regulating the rate of supply to satisfy the change in demand with variation in load.

The Fulton Iron Works is now building two-, three and four-cylinder, four-stroke-cycle engines in capacities of from 100 to 800 b.hp. and will shortly be prepared to build two-stroke-cycle units of capacities ranging from 800 to 3000 b.hp.

T. Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Hunter airs his opinions as to why mine superintendents lack ability to economically operate steam boilers. He points out why the low cost of coal, ignorance and neglect are responsible for the uneconomical conditions existing at so many mine boiler plants.

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During my visits to the mines with Hunter I had noticed that most of the boiler plants were, what would be termed, if found in an ordinary manufacturing plant, in a dilapidated condition. Many of them were old and patched; the iron fronts were cracked and warped with the heat and the settings were anything but samples of economy. Of course, there were exceptions, but on the whole the boiler plants were in bad shape. No attempt had been made to keep the boiler room tidy or the coal off the floor in front of the boilers, Figs. 1 and 2.

Just what the boiler performance was could not be ascertained, because no record was kept of the evaporation of water per pound of coal, nor of anything else that I could find.

As one might expect, this condition did not exist altogether in the plants of the smaller coal companies. In many instances the engine room was some distance from the boiler plant, necessitating a long line of steam piping. In no instance could anyone give even an approximate idea of the amount of condensation in the pipe lines, generally stating that it did not amount to much.

Leaking pipe joints seemed to be the order of the day, Fig. 3, which on account of the length of the pipe lines and manner of suspension were doubtless difficult to prevent, but judging from the amount of steam escaping it must have cost a pretty penny in the course of a year's run. Most boiler houses contained water-tube boilers of some type.

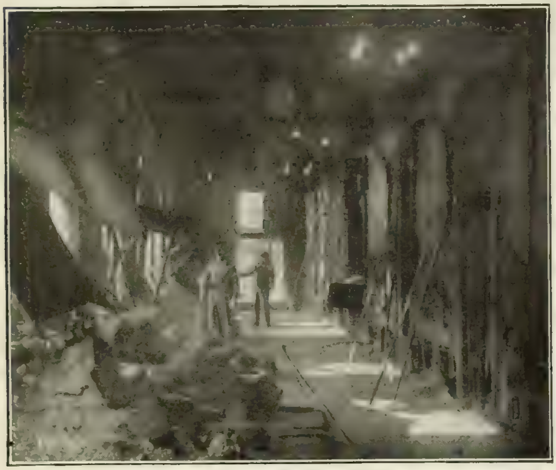


Fig. 1. Typical Return-Tubular Colliery Boiler Plant

"Hunter," said I, when after a tedious climb up a steep hill, we sat down to rest, where we could watch the loaded cars being hauled out of a slope, Fig. 4, "why is it that most mine boiler plants have the appearance of being neglected? You've had enough experience to know."

"Yes, I know. It is due to three of the commonest causes found about a coal mine; cheap coal, ignorance and neglect. One cause is perhaps as responsible as the other."

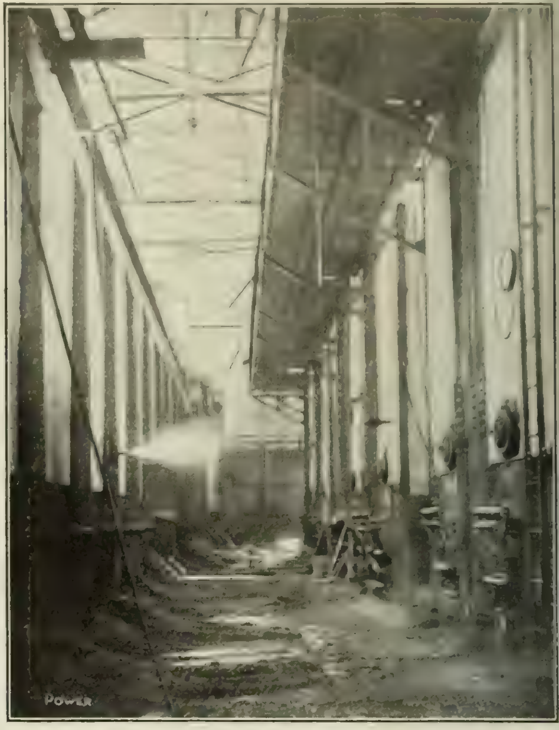


Fig. 2. An Ill-Kept Boiler Room

"I don't understand why any cause should be tolerated. Coal is cheap, of course, and what isn't burned could be turned in for the market, so there is no reason for wasting coal. If only the lowest grade of coal were burned, coal that could not be marketed, even that would not justify a waste of fuel, because more men would be required in the boiler room to attend to the fires."

"Well, cheap coal is, in my opinion, the principal reason why the boiler plant is neglected. If it were necessary to pay, say, $4 a ton, you wouldn't see boilers with tubes plugged and scaled and demanding 20 per cent. more fuel than they should."

"I've seen boilers run with the greater part of the grates covered solid with clinker, because the firemen cleaned the front part of the grate only, when the fires were supposed to have been thoroughly cleaned."

"No intelligence is shown in carrying fires between 20 and 24 in. thick, slicing fires every half hour and firing twice as much coal at a charge than is necessary, believe me. We have found some of these conditions existing in the boiler houses we have visited, and in some of them all were in evidence."

"Well, if the owners don't keep things fixed up, you can't expect the firemen to lose any sleep over the way the boilers are run. Why doesn't the superintendent get after things, he is the man in charge, I believe."

"Now you are getting at the second cause of uneconomical operation. Although the working of the mine depends entirely upon the boiler plant, the majority of mine superintendents pay but little attention to the boilers, so long as they generate enough steam. Uptodate, economical boiler operation cuts a small figure. Give the machines enough steam and the boiler plant is forgotten until something happens."

Hunter stopped talking long enough to throw a piece of slate at a rattlesnake that was sunning itself on a log some distance away, and then resumed his conversation.

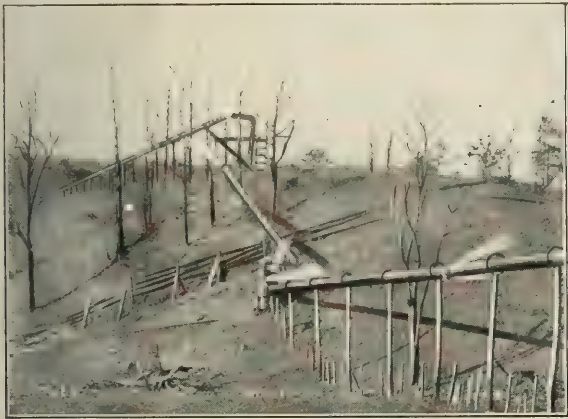


Fig. 3. Leaking Pipe Joints Seem To Be the Order of the Day

Fig. 4. We Rest Awhile after a Climb Up a Steep Hill

"In every boiler room the load on the boilers, draft, condition of the fires and boilers, also the grade of fuel used, are variable factors and, unless studied, it is impossible to get good boiler performance and the fuel consumption will surely be excessive. Just let the string of cars going to a breaker stop and the superintendent is right on the job to find out what caused the stoppage of coal movement and the visible loss of output. In the boiler room, however, coal is moving. Not to the market, but into the boiler furnace. This is a different kind of stoppage, and one the average mine superintendent does not notice."

"You paint the situation rather black," I replied, "all mine boiler plants are not operated under such conditions. We have seen them in which good equipment was found and fairly good operating conditions were maintained."

"Sure, I know that, for there are superintendents who know that any kind of a boiler will not do for colliery work. We have seen a number of boiler plants, and there are plenty more, where high-pressure, water-tube boilers are used. The superintendents operating such boilers are uptodate, and recognize that a good boiler, economically operated, is a mighty good investment."

"It seems to me that if the lower-grade fuel is to be burned, the boilers would have to be designed with plenty of heating surface per horsepower rating. Then shaking grates would come in handy or even stokers."

"Right you are," replied Hunter. "The boilers of the average mine plant are equipped with shaking grates of some type. Stokers, however, are found mostly at mines having a central-power plant from which electrical energy is supplied to several tipples and shafts."

"Why are not stokers used at the average mine boiler plant?" I asked, somewhat surprised now that the matter had been brought to my attention.

Hunter, leisurely cut the end of a fresh cigar, and after lighting it to his satisfaction, and leaning back against the tree trunk with his hands behind his head, said, "What would be the use? Just as much labor would be required and practically as good results can be obtained from hand firing, if attention is given to the method employed, and if the boiler setting is kept in repair and the boilers kept clean.

"I favor shaking grates, because it is easier to burn the refuse of the mine on them, than with stationary grates. When using stationary grates the same precautions should be observed as in any boiler plant, that is, to keep the air spaces open and the grates properly fitted in place. That means the removal of warped grates, because they will allow fuel to drop through into the ashpit. Shaking grates allow cleaning the fires of ashes and fine clinkers without opening the furnace door, and prevent cold air entering the furnace to cool the gases during the operation.

"That is where the fireman comes in," said I, jumping to escape a lump of coal that had fallen from a loaded coal car, and came rolling down the hill. "The superintendent can't stay in the boiler house all the time, and so it's up to the foreman to produce the goods after proper apparatus has been given him with which to work."

"Yes, it is up to the fireman, and superintendent also. If the superintendent does not know enough to put intelligent firemen in front of the boilers, he can't expect to get good results, even with first-class apparatus. You might give a small boy a dollar watch to play with, but you wouldn't even think of letting him so much as touch a $50 one. You know about what would happen if you did.

"Now, putting an ignorant fireman in front of a boiler is as foolish from a practical and economical standpoint as giving a boy a $50 watch with which to play. Both will make a mess of it. Here is where the low cost of fuel comes in. The superintendent says, 'What is the use of paying a fireman high wages when the coal he burns costs so little? He loses sight of the fact that the coal burned in the boiler furnace is worth just as much a ton as the coal that is loaded into cars and shipped to the market.'

"Yes, I have heard it said that a good fireman can save his pay in the saving of coal over what an inefficient fireman would burn. If that is so, why is not the fireman about the most important man about the plant, although giving the engineers all due credit?"

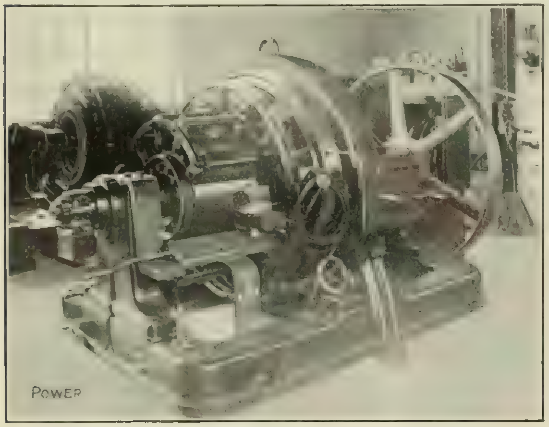
"He is in many respects," replied Hunter, arising and stretching himself. "Come on, let's hike for the hotel and supper. I think I've earned a good one today. At the table, Hunter's actions did not belie his words, and to tell the truth, I was a close second.

* * *

Rig for Truing Commutators

By A. D. Williams

The commutator-truing rig herewith shown is used in the West Breakwater plant of the Pennsylvania R.R., at Cleveland, Ohio. It was designed by J. J. Weick, foreman of the plant, and possesses some novel features, enabling one man to do the work after the rig is in place. A large belt wheel is fixed on the projecting end of the shaft at the slip-ring side of the machine and belted to a 5-hp. direct-current motor. This motor is mounted on a truck with a speed-controlling rheostat and a magnet-switch starting and stopping control, this last being operated from the small control switch on the flexible cord alongside the five-pole double-throw switch on the field frame of the rotary converter. This enables the man working with the rig to stop and start the motor without trouble and the leads to the control switch are long enough to permit his carrying it anywhere around the machine. The large belt wheel is bored to fit the shaft of a large flywheel generator set, which can be seen just beyond the rotary converter, and is bushed down to fit the smaller shafts of the converter and the exciter sets.



Truing Rig in Position

At the time the photograph was taken the machine had just been in use smoothing a commutator with a sandpaper block, which is shown in place of the tool holder. The frame for the rig is made of steel bars, about ¾x6 in., and the tool holder is similar to that used on a lathe having a compound hand feed for regulating the depth of cut, and in addition the tool holder can be fed along the ways by the crank shown just below the oscillating device of the converter. The ways are supported at three points, by a bracket fitting onto the brush holder ring of the machine, by a steel bar strut reaching down with a jack screw and block resting on the floor, and by the Z-bar support to the top of the pillow block. This Z-bar can be made of different lengths to suit other machines. Slotted holes can be used where necessary to permit the adjusting of the tool guide parallel with the shaft of the machine upon which it is to be used, but in this plant the rig has been made with parts to fit the different machines on which it will be used, so that it can be quickly adjusted to them. The rig requires only the removal of two sets of brush-holders in order to set it up.

* * *

Zigler-Holden Safety Switch

The accompanying figures illustrate the Zigler-Holden safety switch which may be used for either alternating- or direct-current service and can be supplied in almost any size desired. The switch is furnished in two types, with or without fuse compartment and clips. Fig. 1 shows a switch installed and Fig. 2 shows the design of a switch with fuse compartment. Where fuses are included the cover is divided into two parts so that the fuse-compartment cover may be removed without exposing the switch itself.

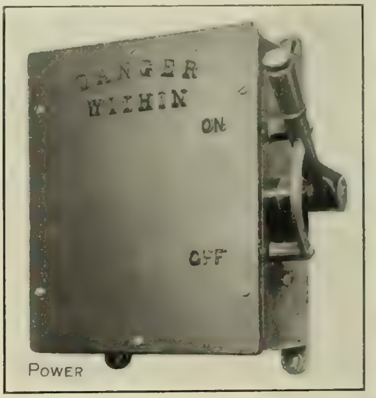


Fig. 1. The Zigler-Holden Safety Switch

The switch blades are mounted on either a hard-wood or porcelain roller journaled in the sides of the box which is of heavy cast iron. The switch is thrown by means of the outside handle *A*, Fig. 2, fitted with the latch *B*. To close the switch the latch must be released and the handle raised the full distance and latched in place. If the handle is not latched in the closed position a recoil spring attached to the roller and the weight of the handle will cause the switch to open and automatically latch itself in the open position. This arrangement makes it impossible for the switch to remain in any but the fully open or closed positions unless it is held. The tension of the spring can be easily adjusted without opening the switch box.

This switch seems as nearly fool proof as it is possible to make such a device, and should be of great value in plants where electric drive makes it necessary that switches be often manipulated by men who are more or less ignorant of the dangers of electric circuits. The design makes it practically impossible for the contacts to burn or fuse and the absence of hinges and hinge belts in the path of the current makes for perfect electrical connection. Its fireproof construction is another point to commend it. Being all standardized the switch parts may easily be renewed.

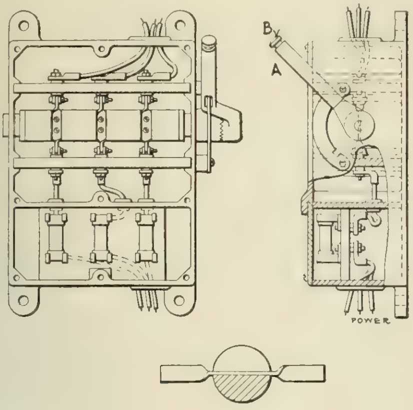


Fig. 2. Details of the Interior of the Zigler-Holden Switch

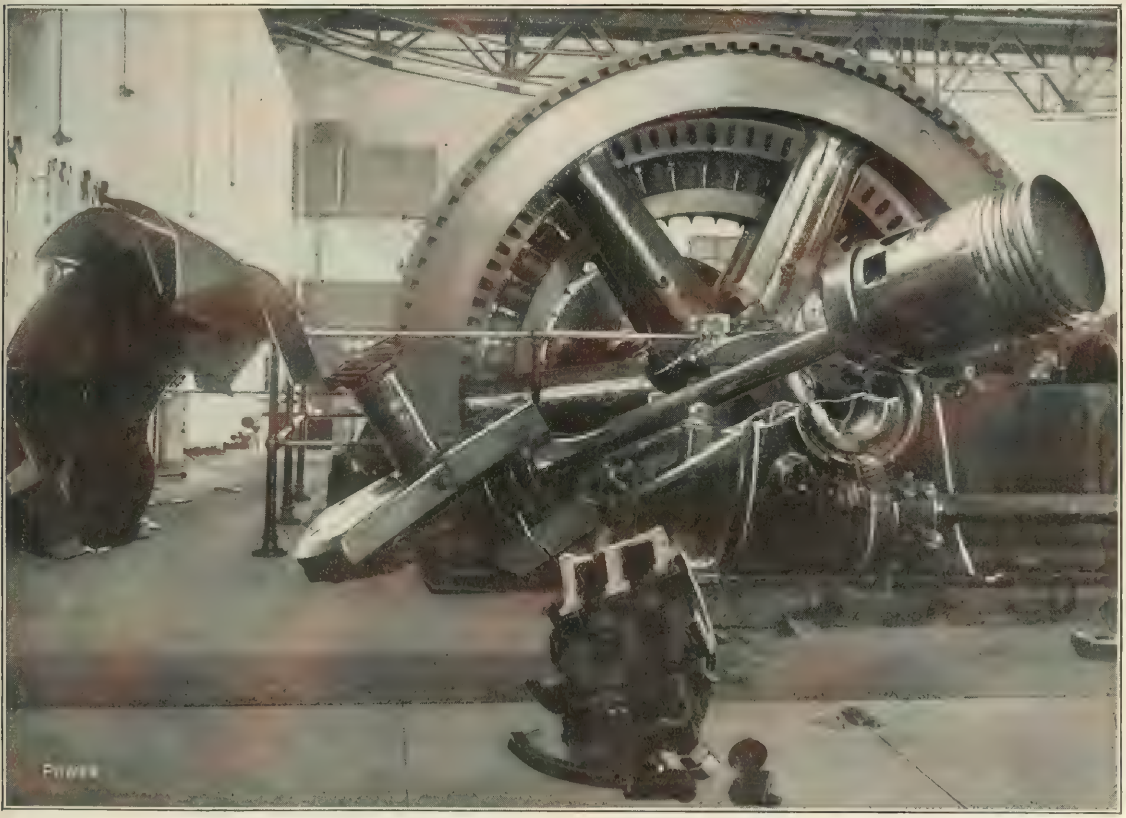
The patents on, and the manufacture of, the Zigler-Holden switch are controlled by the Automatic Safety Electric Switch Co., 1037 Waller Ave., Chicago, Ill.

Wrecked Gas Engine in Mexican Power Plant

By W. A. Wayland

The photograph shows the damage resulting from failure of the main shaft of a 250-hp. Koerting gas engine at the light and power plant at Aguascalientes, Mex. The engine which is of the twin type, running at 180 r.p.m., had been in operation for about five years, giving satisfactory service, and on the night of the accident was in charge of a native mechanic. Although both the crankshaft and the upper half of the bearing were broken off and the piston pulled out of the cylinder, as shown, the wreckage fell clear of the flywheel and the engine continued to run on the other cylinder till morning.

The initial failure appears to have been due to an old crack extending through almost the entire section of the inner crank, the engine apparently having been at work for some time on about ⅞ in. of metal. Nobody was injured.



Wrecked Engine, Showing Piston Pulled out of Cylinder

Measuring the Stresses in a Boiler Shell

The measurement of stress was the subject chosen by Prof. E. G. Coker for the first Kantor lecture of the present session of the (English) Society of Art. The entire lecture was devoted to mechanical methods of measurements, and included an account of the highly ingenious and instructive experiments on rubber models carried out by J. S. Wilson and W. Gore, and Professor Pearson's experiment made with models of jelly. He showed how the shortening of the columns, with the addition of successive stories to the Bankers Trust Co.'s Building in New York, was measured by an extensometer capable of detecting changes of length of 0.0002 in. The portion of his lecture of most immediate interest to POWER readers was his account of a remarkable series of strain measurements made on the steam drum of a Babcock & Wilcox boiler, by S. H. Barraclough and A. J. Gibson, described in a paper printed in the proceedings of the Engineering Association of New South Wales, sessions of 1910 and 1911. Mirror extensometers were used, enabling very accurate measurements to be made even with a very short distance between the gage points. A second mirror was fitted to record by its tilt any flexure of the part under observation. The results are represented in the accompanying diagram reproduced from *Engineering*. It will be seen that the stress is far from equably distributed in the neighborhood of the lap joints, and that it rises to very high values at the corners of the bumped heads where the radius changes for the flange.

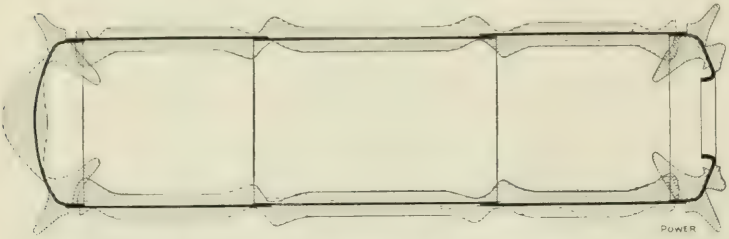


DIAGRAM OF STRESSES IN A BABCOCK & WILCOX BOILER DRUM

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Compression or Absorption Ice Plant

Before the Southwestern Ice Manufacturers Association, at the annual convention in Marlin, Tex., L. C. Nordmeyer read an interesting paper on the above subject. The author realized that in a short paper it was impossible to compare these two types of plant for any and all conditions. A selection was made of the conditions and comparative data given of two 50-ton plants. As most of the refrigerating plants in the Southwest are ice plants, and as the great majority operate during the summer months with high-temperature water, an ice-making plant using a cooling tower delivering water at an average temperature of 85 deg. F. for condensing and cooling purposes was chosen. The capacity of 50 tons was selected, as this seems to be the average size of plant in this vicinity. The conditions on which the investigation was made are as follows:

Heat value of coal, B.t.u.	12,000
Efficiency of boiler, per cent	60
Temperature of condensing water from tower, deg. F	85
Source of supply	City Water
Water circulated per minute for condensing purposes in compression plant at 4½ gal. per min. per ton	225
Water circulated per minute for condensing purposes in absorption plant at 3½ gal. per min. per ton	175
Height to which water must be pumped in each case, ft	60
Hp. required for pumping water in compression plant	6
Hp. required for pumping water in absorption plant	11
Cooling tower capacity for compression plant, gal	324,000
Cooling tower capacity for absorption plant, gal	684,000
Water loss through evaporation in each case, per cent	10
Hp. to drive cooling tower fan, compression plant	5
Hp. to drive cooling tower fan, absorption plant	12
Hp. to drive freezing tank agitator	4
Hp. for electric light and air compressor	10
I.hp. of aqua pump	9
Cost coal per ton (assumed in bins)	$2
Cost 1000 gal. city water (assumed) in cents	10
Cost cooling tower in compression plant with motor	$2600
Cost cooling tower in absorption plant with motor	$4150
Freight rate (approximate per 100 lb.) in cents	97
Salary to day engineer per day	$3.33
Salary to night engineer per night	$2.50
Wages paid ice pullers per day	$1.75
Wages paid firemen per day	$2.00
Interest on money invested, per cent	6
Depreciation and obsolescence, per cent	5
Insurance and taxes, per cent	1½

Of the average ice-making plant, the annual output is approximately 60 per cent. of the total possible annual capacity, so that in establishing cost per ton of ice produced, as affected by charges which are not directly as the tonnage, 60 per cent. of the possible output has been taken as the quantity of ice made. Thus:

$$365 \times 50 \times 0.6 = 10{,}950 \textit{ tons per year}$$

The cost of the building, including boiler and engine rooms, freezing tank room and daily ice storage, complete, including insulation, will be approximately $20,000. For either type of plant the fixed charges on the building will be: Interest, 6 per cent.; insurance and taxes, 1½ per cent.; depreciation, 5 per cent.; making a total of 12½ per cent. on $20,000, which would be $2500 per year. As the total ice output for the year is 10,950 tons, the building charge per ton will be

$$\$2500 \div 10{,}950 = \$0.228$$

COMPRESSION PLANT

In the compression plant the mechanical equipment includes a standard compressor and complete apparatus for freezing distilled water in the cans, including all insulation brine and ammonia, three return-tubular boilers one being a spare unit, together with required brickwork and stack, water-circulating pumps, a 300,000-gal. cooling tower, a 20-kw. engine and generator. All the auxiliary machinery except the boiler-feed pump is to be electrically driven. The water-circulating pumps are to be in duplicate, and one of these is to be steam driven. The cost for the mechanical equipment erected, including foundations and engineering charges, complete, will be $42,265. The total cost of the plant, including building and machinery, will thus be $62,265. There will be burned 11½ tons or 23,000 lb. of coal in 24 hr. when producing full capacity, so that the fuel per ton of ice will cost

$$\frac{23{,}000 \times 2}{2000 \times 50} = \$0.46$$

The operating cost was estimated as follows:

Two firemen at $720 per year	$1,440
Two engineers	2,100
Handy man	720
Oil, waste, small supplies, etc. (includes 25 per cent ammonia loss)	450
Total	$4,710

Dividing the $4710 by 10,950 gives a cost per ton of ice of $0.43. Adding to this 7c. for ice handling makes a total operating expense, exclusive of coal, of 50c. per ton of ice.

In obtaining the fixed charges on the mechanical equipment, an allowance of 6 per cent. was made for interest on the machinery investment, 1½ per cent. for insurance and taxes, and 5 per cent. for depreciation and obsolescence, making a total of 12½ per cent. on $42,265, or $5283. Dividing by the annual output of the plant gives $0.482 per ton of ice as the fixed mechanical charge.

In the cooling tower, the water loss which must be made up, will be 10 per cent. of 324,000 gal., or 32,400 gal. per day. At 10c. per 1000 gal. this will cost $3.20 per day, or $0.064 per ton of ice. Collecting the above items gives the following total cost of ice per ton:

Water	$0.064
Fixed mechanical cost	0.482
Fuel	0.46
Operating expense	0.50
Total	$1.506
Fixed building cost	0.228
Total cost	$1.734

ABSORPTION PLANT

In the absorption plant the same average annual output of ice as compared with the capacity of the plant, is considered, and the same fixed building charge of $0.228 per ton of ice. The mechanical equipment of the plant includes a complete standard absorption machine and apparatus for freezing distilled water in cans, using evaporators to supply the necessary distilled water not supplied by other apparatus, all insulation, brine and ammonia included, two return-tubular boilers, one being a spare, together with required brickwork and stack, water-circulating pumps, a 700,000-gal. water-cooling tower, and a 30-kw. engine and generator. All the auxiliary machinery except the boiler feed and aqua pumps is to be electrically driven, and as before, the water-circulating pumps are to be in duplicate, one of them being steam driven.

The cost of the mechanical equipment erected, including foundations and engineering charges, will be $46,845, and the total cost of the plant, building and machinery will be $66,845. To produce full capacity will require 15,480 lb. of coal in 24 hr., making the fuel cost per ton of ice

$$\frac{15{,}480 \times 2}{2000 \times 50} = \$0.3096$$

The operating cost is given in the following:

Firemen	$1,440
Engineers	2,100
Handy man	720
Oil, waste, small supplies and ammonia	300
Total	$4,560

The total, $4560, divided by the annual output of ice, gives a charge of $0.416 per ton of ice. Adding 7c. for ice handling, makes the operating expense $0.486 per ton of ice.

For the fixed charges on the mechanical equipment, the same percentages are allowed. Thus, 12½ per cent. of $46,845 would be $5855, and dividing by the annual output in tons gives $0.535 per ton of ice. The water loss on the cooling tower will be 10 per cent. of 684,000 gal., or 68,400 gal. per day. This, at 10c. per 1000 gal. will cost $6.84 per day, or $0.137 per ton of ice. Summing up, the total cost per ton of ice is as follows:

Water	$0.137
Fixed mechanical charge	0.535
Fuel	0.3096
Operating cost	0.486
Total	$1.4676
Fixed building cost	0.228
Total cost	$1.6956

From the above comparison there is a difference of nearly 4c. per ton in favor of the absorption plant. However, it is only fair to point out that the absorption machine actually uses more heat than the compression machine, but gains in efficiency because of the inefficiency of the steam engine. It is thus apparent that compounding the engine in the compression plant under discussion would better the economy and reduce the cost per ton to approximately that of the absorption plant.

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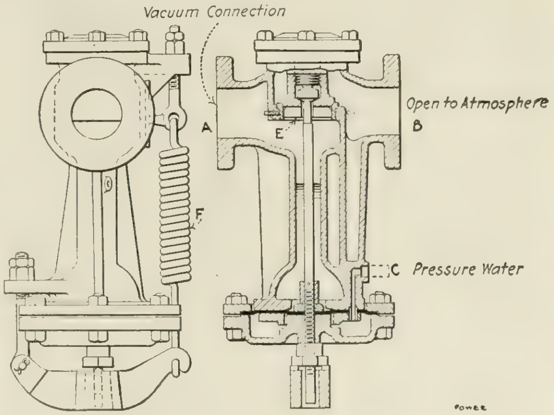
Auld Vacuum Breaker

A new vacuum breaker, known as the Auld, is shown herewith. It is used in connection with jet condensers, especially if the condenser is located on a higher level and a considerable distance removed from the exhaust outlet of the turbine or engine. The vacuum breaker, manufactured by Schutte & Koerting Co., Twelfth and Thompson Sts., Philadelphia, Penn., is connected on or near the exhaust outlet of the machine by its below-seat port *A*, the above-seat port *B* being open to the atmosphere.



DETAILS OF AULD VACUUM BREAKER

A connection is made at *C* with the circulating-water inlet at the condenser; the operation is as follows:

As the pressure of the injection water, to maintain the proper vacuum and insure efficient operation of the condenser, must not go below a fixed minimum (approximately 10 lb. per sq.in.), the vacuum breaker is so adjusted that a reduction of more than 2 lb. in the water pressure will open the valve. This is accomplished by water entering through the inlet *C*, which is fitted to the under side of the diaphragm, thus holding the valve shut against the opening action of the adjustable spring *F*. Therefore, if the pressure of the water is reduced the spring will overbalance the pressure exerted below the diaphragm, thus opening the valve and destroying the vacuum.

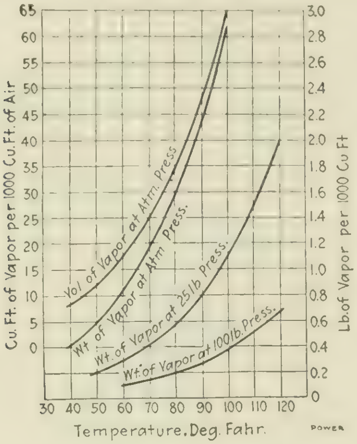
Moisture in Compressed Air

By A. Hofmann

SYNOPSIS—Some specific examples showing the amount of moisture present at different temperatures and pressures, the importance of cooling the air, the loss of work caused by moisture and the proportion of cooling water it requires.

⁂

Every user of compressed air knows that moisture in air is to be avoided, if possible, when the air is used in pneumatic tools, drills or, in fact, in any reciprocating mechanism. It is also generally known how the trouble due to moisture is brought about; namely, by the vapor condensing while expanding in the air-operated tool. The drop in temperature which takes place during expansion causes the water formed to freeze, clogging up the passages of the mechanism, or if actual freezing does not take place, at least the water formed washes out the lubricant, causing the tool to wear out rapidly. The usual method of eliminating moisture from compressed air is by cooling the air after it leaves the compressor, thus depositing a portion of the moisture before it enters the pipe lines, and one of the objects of this article is to show just how effective an aftercooler is in removing this moisture at different degrees of cooling.



Vapor in Air at Different Pressures and Temperatures

Moisture Removed by Aftercooler

Atmospheric air always contains a certain amount of moisture and this exists as a vapor or steam gas, and when present in the air it behaves in every way like steam; it exerts a pressure, the amount of which depends upon the temperature and the quantity of moisture present. At a given temperature air can hold a fixed maximum weight of moisture and when it contains this maximum amount the air is said to be saturated. Air containing moisture behaves in accordance with Dalton's law on mixture of gases, that is, each gas or vapor in a mixture exerts its own pressure and the total pressure of the mixture is the sum of the pressures exerted by the gases independently. Thus, take atmospheric air at 80 deg. F., if the air is saturated with moisture the pressure exerted by the vapor will be the pressure of saturated steam at a temperature of 80 deg. F., which is according to any steam table 0.505 lb. per sq.in. abs. Therefore, if the total pressure of the atmosphere is 14.7, the pressure exerted by the air must be 14.7 less 0.505, which equals 14.195 lb. per sq.in. If, now, instead of being saturated the air contains only 70 per cent. of the maximum amount it can hold, that is to say, the relative humidity of the air is 70 per cent.; then the pressure exerted by the vapor would have been only

$$0.7 \times 0.505 = 0.3535$$

and the pressure exerted by the air would be

$$14.7 - 0.3535 = 14.3465$$

When the mixture of air and vapor enters a compressor the vapor again behaves like any gas, that is, it is compressed adiabatically with the air. The vapor then becomes in every sense a steam gas and at the end of compression it is highly superheated, and only by reducing its temperature can the vapor be deposited as water. *Vice versa*, when compressed air containing this vapor is used in any mechanism where it is expanded, the vapor or steam gas is expanded adiabatically, and as every engineer knows when steam is expanded in this way a temperature reduction takes place and a portion of the steam is condensed, and it is this condensation which causes so much annoyance in the air-operated tool.

The volume of vapor which any volume of air contains can be calculated from the following simple formula:

$$V_s = \frac{Vp_s}{p}$$

where

V_s = Volume of vapor in cubic feet at pressure p,
V = Volume of air and vapor in cubic feet at pressure p;
p = Absolute pressure of air and vapor per square inch; thus at sea level and atmospheric conditions $p = 14.7$;
p_s = Absolute pressure per square inch exerted by the vapor.

Thus, if the mixture is saturated p_s equals the pressure of saturated steam obtained from a steam table at the temperature under consideration.

The weight of vapor present will be $V \times D$, where D is the weight of vapor per cubic foot and if the air is saturated D equals the weight per cubic foot of saturated steam taken from a steam table at the temperature in question.

In the accompanying diagram is shown the volume of vapor in cubic feet which 1000 cu.ft. of air contains at atmospheric pressure when saturated and at different temperatures. Thus, if the temperature of air is 80 deg. F., the pressure exerted by the vapor is 0.505. The volume V_s of the vapor is according to the above formula:

$$\frac{1000 \times 0.505}{14.7} = 34.3 \textit{ cu.ft.}$$

And this is the quantity also shown by the diagram.

Curves are also given showing the weight of vapor which 1000 cu.ft. of air at atmospheric pressure, 14.7 lb.

per sq.in., can hold at different temperatures as well as the vapor which 1000 cu.ft. of free air can contain at 25 lb. gage pressure and 100 lb. gage pressure per square inch. Thus at 60 deg. F. the weight of vapor is 0.8 lb. at atmospheric pressure and at 80 deg. F. it is nearly 1.6 lb. or twice that at 60 deg. From these diagrams it can be determined exactly how much vapor remains in the air after being compressed and then cooled in an aftercooler. For instance, if air is taken into a compressor at 80 deg. F. and if it is saturated with vapor, 1000 cu.ft. of air will contain 1.6 lb. of vapor, and if the humidity is 70 per cent., the amount of vapor will be

$$0.7 \times 1.6 = 1.12\ lb.$$

If, now, this air is compressed in a two-stage compressor to 100 lb. discharge pressure, the intercooler pressure will be about 25 lb. If water is supplied the intercooler at 60 deg. F., the air will leave the intercooler at about 80 deg., and the amount of vapor 1000 cu.ft. of air at 25 lb. pressure can contain is found from the diagram to be nearly 0.6 lb. In other words, 1.12 lb. less 0.6 equals 0.5 lb. of vapor has been removed by the intercooler, or 45 per cent. of the moisture originally in the air. If, now, the air leaves the compressor at 100 lb. pressure and is cooled in an aftercooler to 80 deg. F., the diagram shows the moisture still in the air to be 0.2 lb., or 18 per cent. of what air was there originally, that is, the intercooler has removed 45 per cent. and the aftercooler 36 per cent. of the vapor.

If instead of cooling the air in the aftercooler down to 80 deg. it had been cooled down to 60 deg., the vapor remaining would only have been 0.1 lb., or 9 per cent., of what it originally contained, and this shows the great importance of cooling the air down to the lowest possible temperature. In the case just cited, by cooling 20 deg. lower, that is, from 80 to 60 deg., one-half of the moisture the air contained was eliminated. Take another example. If the air enters the compressor at 60 deg. F. and 70 per cent. humidity it will contain about 0.56 lb. of moisture, and if on account of insufficient cooling surface the air can be cooled down to only 110 deg. in the aftercooler, practically all of the moisture originally in the air will remain after it has been compressed to 100 lb.

In order then to get all but a small percentage of the vapor out of the air it must be cooled to a low temperature. It is impossible to remove all of the moisture and if the air is used at the same temperature as it leaves the cooler, it will be saturated with moisture and water will deposit when expansion takes place in the tools. To entirely prevent the deposit of moisture, the air must be cooled to a much lower temperature than that which it enters the tools, or what amounts to the same thing, the air must first be cooled and then reheated before it is used.

Moisture Causes Loss of Work

There is another phase of this question to be considered. That is, how does the moisture in the air affect the work done by the compressor? It has already been stated that the vapor must be compressed the same as the air; therefore, the work required to compress the vapor must be considered as lost work since the vapor is eventually practically all deposited as water in the intercooler, aftercooler or pipe lines, and does no work in the tools. For instance, with 1000 cu.ft. of air entering the compressor at 80 deg. F. and 70 per cent. humidity, as before, the vapor will occupy a volume of 34.3 cu.ft. at saturation or

$$0.7 \times 34.3 = 24\ cu.ft.$$

at 70 per cent. humidity. This is equal to 2.4 per cent. of the total volume of 1000 cu.ft. In other words, the volumetric loss due to vapor is 2.4 per cent. If compression takes place in one stage to 100 lb., the work required to compress 24 cu.ft. of vapor will also be 2.4 per cent. of the total work, or 2.4 per cent. represents the work lost in compressing the vapor. If compression takes place in two stages, the loss is a little less because the vapor that is removed by the intercooler does not have to be compressed in the high-pressure cylinder. Calculation shows in the above case for two-stage compression that the lost work will be about 2 per cent. If the air enters the compressor at 100 deg. F. and 80 per cent. humidity, the same reasoning shows that with single-stage compression the lost work is about 5 per cent. and with two-stage compression about 4 per cent.

This is a loss in compression of air ordinarily not considered. It is true that most users of air compressors know the importance of taking air into the compressor at as low a temperature as possible, and the reasons, of course, are that by so doing a greater weight of air is compressed with a given amount of power expended. In addition to this the air should be taken into the compressor as cold as possible so as to reduce the lost work due to compressing the vapor. For instance, if air is taken from a warm engine room close to 100 deg. temperature and laden with moisture, the figures show that the loss due to compressing moisture may be as high as 5 or 6 per cent. of the total work done.

Cooling Water Required by Water Vapor

Finally, there is one other question to be considered in connection with moisture in the air; that is, what percentage of the total water supplied to the intercooler or aftercooler is used to cool and extract the vapor in the air. Suppose, as before, the air enters the compressor at 80 deg. F. and 70 per cent. humidity, then if the temperature of the air leaving the low-pressure cylinder in a two-stage compressor is 250 deg., and the air is cooled down to 80 deg. F. in the intercooler, the volume of air and vapor being 1000 cu.ft., the volume of vapor alone is 24 and the volume of air is 976 cu.ft. The weight of this air will be 71.8 lb. and the heat extracted from the air will be the weight multiplied by its specific heat and by the reduction of temperature; that is,

$$71.8 \times 0.237\ (250 - 80) = 2893\ B.t.u.$$

The weight of the vapor contained in the air as before is 1.12 lb. This must be cooled from 250 to 80 deg., and as the specific heat of the vapor is about 0.46, the heat extracted will be

$$1.12\ (250 - 80)\ 0.46 = 87\ B.t.u.$$

To this must be added the latent heat of the 0.5 lb. of vapor which is actually deposited in the cooler. The latent heat of steam at 0.5 lb. abs. pressure is 1046, which, multiplied by 0.5 gives 523 B.t.u. The total heat, therefore, given up by the vapor will be

$$87 + 523 = 610\ B.t.u.$$

and the entire heat removed by the water in the cooler contained both in the air and the vapor will be

$$2893 + 610 = 3503\ B.t.u.$$

In other words, of the total heat extracted 610 B.t.u., or 17.4 per cent., is taken from the vapor in the air; namely, 17.4 per cent. of the water used is required by the vapor—a most surprising result.

Specifications for the Purchase of Oil

By J. J. McIntosh

SYNOPSIS—General specifications for the purchase of fuel oil as used by the government and a typical example of the type of contract used by many plants.

⁂

Every plant burning oil should incorporate in the contract the amount of impurities permissible in the oil shipments, and every shipment should be tested to see that the terms of the contract are being lived up to. It is a fact that many plants pay no attention to the quality of the fuel they are receiving, and, as a result of their negligence, many of them experience considerable trouble and poor economy in the burning of oil as fuel. Oil as taken from the wells must be properly treated to eliminate the water, gravel and other débris which it contains. In many cases the oil as received at the plants contains large percentages of impurities. Unless the oil is being supplied under a proper form of contract, and each and every shipment tested, these impurities are not only causing trouble and poor economy, but they are being paid for the same as fuel.

The above was forcibly brought home to the manager of a certain company operating in the West. In this instance the form of contract was similar to the one (hereinafter shown) between the city of Phoenix and the Union Oil Co. of California. Unfortunately, this company did not test its oil shipments for nearly a year after operating under this contract. Their operating engineer finally persuaded them to supply him with a reliable oil thief and apparatus to test for impurities. At the end of the first six months after testing their oil shipments, they received a rebate of $2675.

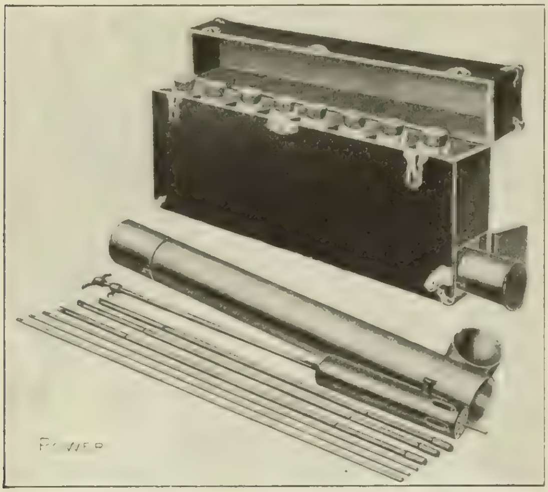


Fig. 1. Type of Oil Thief for Taking Samples

Testing of fuel oil for water and impurities is comparatively a simple matter. The operating engineer can, with a little study, carry on these tests himself and thus make himself more valuable to his company. It must be remembered that fuel oil (unlike coal) shipments received from the same field have, generally speaking, a nearly uniform heat value when freed from water and débris. It is not necessary, therefore, to carry on tests to determine its heat value only insofar as it contains the impurities mentioned above.

In Fig. 1 is shown a type of oil thief for taking samples from oil shipments for testing purposes. In Fig. 2 is shown an apparatus for testing oil for b.s. (brown sediment) and water. Each of the four metal tubes shown in the illustration contains a glass tube graduated in cubic centimeters. The samples to be tested are placed in the tubes and an equal portion of gasoline is added. The rotating element is then revolved at the proper speed for about 15 min. When the tubes are removed from the apparatus there is a well defined line between b.s., water and oil. In this way the percentage of b.s. and water in the oil shipment is easily determined. The above pieces of apparatus are being used to a considerable extent by operating engineers of oil-burning plants.

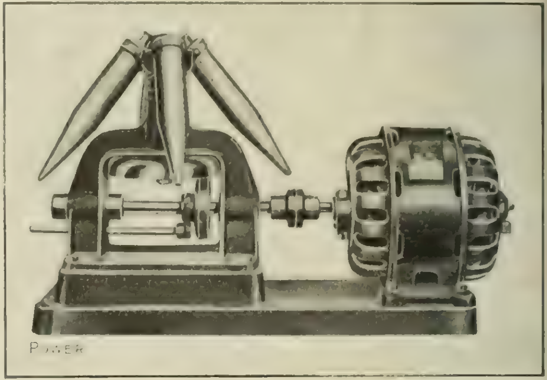


Fig. 2. Apparatus to Test Oil for Brown Sediment and Water

Specifications for the purchase of fuel oil become more rigid each year. Up to within a few years ago oil was bought with little or no regard to the amount of water or other impurities it might contain. A fuel-oil agreement that called for the necessary number of barrels and the price per barrel was considered by the purchaser as being all that could be desired. Below are given the general specifications for the purchase of fuel oil as used by the government:

(1) In determining the award of a contract, consideration will be given to the quality of the fuel offered by the bidders, as well as the price, and should it appear to be to the best interest of the government to award a contract at a higher price than that named in the lowest bid or bids received, the contract will be so awarded.

(2) Fuel oil should be either a natural homogeneous, or a homogeneous residual from a natural oil; if the latter, all constituents having a low flash point should have been removed by distillation; it should not be composed of a light oil and a heavy residue mixed in such proportions as to give the density desired.

(3) It should not have been distilled at a temperature high enough to burn it, nor at a temperature so high that flecks of carbonaceous matter begin to separate.

(4) It should not flash below 60 deg. C. or 140 deg. F., in a closed Abel-Pensky or Pensky-Martins tester.

(5) The specific gravity should range from 0.85 to 0.96 at 15 deg. C. or 59 deg. F.; the oil should be rejected if its specific gravity is above 0.97 at that temperature.

(6) It should be mobile, free from solid or semi-solid bodies, and should flow readily, at ordinary atmospheric temperatures and under a head of 1 ft. of oil, through a 4-in. pipe 10 ft. in length.

(7) It should not congeal nor become too sluggish to flow at 0 deg. C. or 32 deg. F.

(8) It should have a calorific value of not less than 10,000 calories per gram (18,000 B.t.u. per lb.); 10,250 calories to be standard. A bonus is to be paid or a penalty deducted according to the method under section 21, as the fuel oil delivered is above or below the standard.

(9) It should be rejected if it contains more than 2 per cent. water.

(10) It should be rejected if it contains more than 1 per cent. sulphur.

(11) It should not contain more than a trace of sand, clay or dirt.

(12) Each bidder must submit an accurate statement regarding the fuel he proposes to furnish. This statement must show:

(a) The commercial name of the oil.

(b) The name or designation of the field from which the oil is obtained.

(c) Whether the oil is a crude oil, a refinery residue, or a distillate.

(d) The name and location of the refinery, if the oil has been refined at all.

(13) The fuel oil is to be delivered f.o.b. cars or vessels, according to the manner of shipment, at such places, at such time, and in such quantities as may be required, during the fiscal year ending. . . . . .

(14) Should the contractor, for any reason, fail to comply with a written order to make delivery, the Government is to be at liberty to buy oil in the open market and charge against the contractor any excess of price, above the contract price, of the fuel oil so purchased.

(19) A contract entered under the terms of these specifications shall not be binding if, as the result of a practical service test of reasonable duration, the fuel oil fails to give satisfactory results.

(20) It is understood that the fuel oil delivered during the term of the contract shall be of the quality specified. The frequent or continued failure of the contractor to deliver oil of the specified quality will be considered sufficient cause for the cancellation of the contract.

(21) Payment for deliveries will be made on the basis of the price named in the proposal for the fuel oil corrected for variations in heat value, as shown by analysis, above or below the standard fixed by the contractor. This correction is a pro rata one and the price is to be determined by the following formula:

$$\frac{\text{delivered calories per gram (or B.t.u. per lb.)} \times \text{contract price}}{\text{standard calories per gram (or B.t.u. per lb.)}} = \text{price to be paid}$$

Water that accumulates in the receiving tank will be drawn off and measured periodically. Proper reduction will be made by subtracting the weight of the water from the weight of the oil deliveries.

The specifications given above provide for the purchase of fuel oil by weight. As such oil is frequently delivered by volume, it is important to note the temperature of a delivery and to allow for the expansion due to this temperature when computing the weight of the delivery from the volume. From the volume of the oil at the temperature of delivery, the volume at standard temperature, 15 deg. C., or 59 deg. F., should be computed in the manner given below.

The coefficient of expansion of ordinary fuel-oil residue, of asphaltic base, is approximately 0.0006 per 1 deg. C.

Hence, if the temperature of the delivery is above 15 deg. C., then

$$(X\ \textit{deg. C.} - 15\ \textit{deg. C.}) \times 0.0006 = \textit{Correction}$$

This correction is to be added to the specific gravity at the higher temperature to give the standard specific gravity at 15 deg. C.

If the temperature of the oil delivered is below 15 deg. C., the correction is to be subtracted from the specific gravity at 15 deg. C.

Since a gallon of water at a temperature of 15 deg. C. weighs 8.3316 lb., the weight in pounds of a gallon of oil at 15 deg. C. is 8.3316 times the specific gravity of the oil at that temperature.

Similarily, since a cubic foot of water at 15 deg. C. weighs 62.3425 lb., the weight in pounds of a cubic foot of oil at 15 deg. C. is 62.3425 times its specific gravity at that temperature.

Following are given the principal items from a fuel-oil agreement in force between a railroad company and a large oil company, both of whom are operating in the Southwest:

(1) Oil to be crude petroleum in its crude or natural state, or the product of crude petroleum, distilled or reduced.

(2) Gravity of oil to be between 13 and 26 deg. Baumé at 60 deg. F.

(3) Oil must not contain water, sand or other foreign matter in excess of 2 per cent.

(4) Oil to be paid for on the basis of volume at 60 deg. F. after deducting the percentage of water and foreign matter as may be shown by test outlined below.

(5) Samples for testing to be taken by means of a car thief from each car load, or fraction thereof. Oil thus obtained to be tested for brown sediment, sand and water. The percentage of brown sediment, sand and water will be determined by the gasoline test.

(6) Should the oil tested contain in excess of the specified amount of water and other impurities, the shipment represented by it will not be accepted, but will be returned to the owners, who shall be responsible for the freight charges, both ways, on the rejected shipment.

To show the different contracts which are in use for the purchase of fuel oil the agreement now in force between the water-works of the city of Phoenix and one of the largest oil companies operating in California is given in the following. It is a typical example of the type of contract a great many plants are working under:

This agreement, made in duplicate this eleventh (11th) day of January, 1910, between Union Oil Company of California, a corporation, party of the first part, and the Common Council of the City of Phœnix, Arizona, hereinafter called the party of the second part.

Witnessed, that in consideration of the mutual covenants hereinafter contained, the party of the first part agrees to sell and deliver, and the party of the second part agrees to use oil as fuel at Phœnix, Arizona, and to purchase, take and receive from said party of the first part all the fuel oil that said party of the second may require for its own consumption at the place, during the time and at the price or prices hereinafter mentioned, to-wit:

Quantity: The party of the first part shall not be compelled to deliver to the party of the second part, during the term of this agreement, more than one thousand barrels of forty-two (42) gallons each in any one calendar month, but the party of the second part agrees not to buy any fuel oil from any other person, firm or corporation other than the party of the first part, so long as the party of the first part is ready, willing and able to supply all the fuel oil requirements of said party of the second part, on the terms herein specified.

Quality: Said fuel oil shall not be heavier than fourteen degrees Baumé at 60 deg. F. If said oil shall contain water and sand in excess of one per cent., as shown by the gasoline test, then said party of the second part shall be entitled to such excess at the price herein mentioned, provided claim therefor is made within ten days after delivery thereof.

Point of delivery: Said fuel oil shall be delivered at Phœnix, Arizona.

Said party of the second part agrees to give ten days' notice of its said requirements, and to provide suitable and sufficient tanks to promptly receive and store said oil.

Price: The price or prices to be paid for said fuel oil per barrel of forty-two (42) gallons each, shall be as follows: One dollar and sixty-five cents per barrel ($1.65); based on present freight rates of $6 per ton. If freight rates should increase or decrease during the life of this contract, then such increase or decrease of freight shall be added to or deducted from the above price of oil per barrel delivered as hereinbefore specified.

Terms of Payment. All deliveries hereunder in any calendar month shall be settled and paid for in United States gold coin at the price or prices aforesaid not later than the tenth day of the next succeeding month. Default in any payment for a period of ten days shall justify the cancellation of this contract, but if said contract is not canceled therefor, and while such delinquency continues, the party of the first part may require payment on all deliveries made.

Liability. It is further mutually agreed that neither of the parties hereto shall be liable for any delays or damages occasioned by or arising from strikes or other labor disturbances, earthquakes, fire, action of the elements, war, insurrection, riot or rebellion, or interference by civil authorities and the party of the first is not to be liable in the event of failure of railroad, or other transportation, not controlled by it nor in the event of its inability to procure tank cars from the railroad company for making deliveries hereunder.

Should party of the second part sell or dispose of its plant or should the same cease to be operated for a period of ninety days continuously, the party of the first part shall have the right to cancel this contract, by giving said second party written notice of its election so to do.

*

Progress on Panama-Pacific Exposition

Construction work on the numerous large wooden buildings for the Panama-Pacific International Exposition at San Francisco is making rapid progress. Among the principal buildings already erected are the Palace of Machinery, covering three acres, the Fire House, the Education Building, the passenger station, and warehouses, ferry slips and oil houses. The framework has been started for the buildings for Mines and Metallurgy, Various Industries, Manufactures, Liberal Arts, Food Products and Agriculture.

Thirty-five states and territories and certain of the foreign governments have announced their intentions to secure space; 177 congresses and conventions have been arranged to meet in San Francisco during the fair, and an attendance of from 10,000,000 to 18,000,000 is anticipated for the exposition. It is said that neither Germany nor England will take exhibit space.

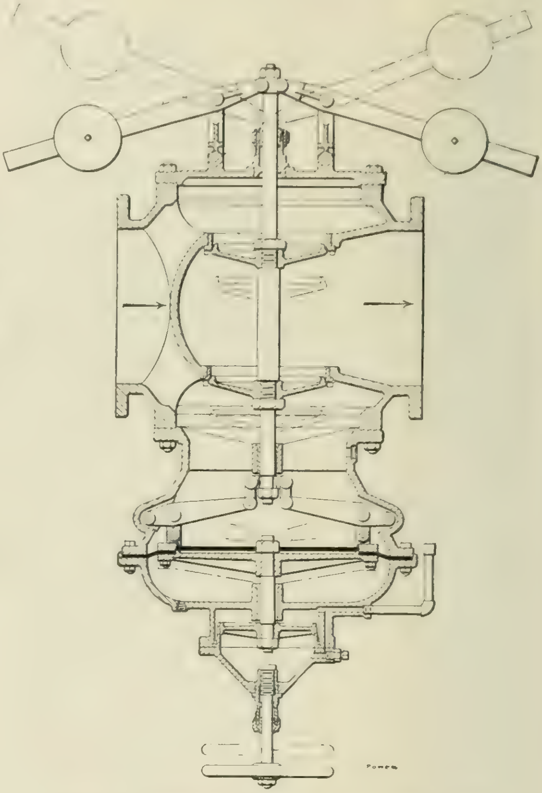
The cost of the exposition is estimated at $80,000,000, of which the state of California and the city of San Francisco will each pay $5,000,000, San Francisco subscribes $7,500,000 and individual exhibitors $25,000,000.

*

Schutte Automatic Flow-Regulating Valve

This flow-regulating valve, illustrated herewith, is used on the low-pressure steam supply to mixed-pressure turbines which operate on an intermittent supply of exhaust steam from engines, pumps, etc., and partially on high-pressure steam through a separate valve when the low-pressure supply is cut off. The function of this valve is to maintain a steady pressure to the turbine of 16 to 17 lb. absolute and to close when the pressure drops below 15 lb. absolute, due to the insufficient supply of exhaust steam from the engines. The object is to prevent the loss of vacuum and consequently reduced efficiency of the turbine.

This valve, which is manufactured by the Schutte & Koerting Co., Twelfth and Thompson Sts., Philadelphia, Penn., as the section shows, is of the double-seat type, globe body, with a water chamber below which is in communication with the inlet side of the body, at the bottom of which is a large rubber diaphragm, constantly submerged and thus protected against the heat of the steam. The diaphragm is connected to the valve spindle by means of multiplying levers so that the motion of the diaphragm is relatively small as compared with the movement of the valve disks. A dashpot is fitted below the diaphragm to absorb sudden shocks and in the bottom cover of this a screw spindle with handwheel is placed, by means of which the disks can be forced to the seat for closing the valve. The spindle passes through a stuffing-box in the upper cover above which it attaches to the balancing levers fitted with adjustable weights.



Section through Flow-Regulating Valve

The adjustment is such that any increase in pressure over zero gage will open the valve and any reduction in pressure below zero will close it. A hydraulic closing cylinder can be fitted at the top when so desired for closing the valve from a distance by means of pressure water, controlled by a three-way cock. This valve can only be built in the globe form, as shown.

*

To Develop 52,000 Hp.—Another hydro-electric development planned on Cheat River in West Virginia is that of the West Virginia Development Co., This water power is at the Beaver Hole site, about 13 miles from the Pennsylvania state line, and is estimated to develop about 52,000 hp. for use in West Virginia and southwestern Pennsylvania markets. The company has not determined upon definite plans for beginning construction, but proposes a dam about 1200 ft. long and 100 ft. high, with the power house built in and forming part of the dam.

Editorials

Control of the Water Powers

If the price of eggs goes up to eight or ten cents a piece, one may go without them; if your shoeblack or barber doubles the price of his services, you may shine and shave yourself. If the electric company persists in charging much more for its service than it is considered worth, a community may, in its corporate capacity, make the current itself and distribute it at cost. The best defense on the part of an individual or of the people collectively against extortion is the ability to do for themselves.

But there are some things which the people think they cannot do, and under present circumstances probably cannot do, short of an industrial revolution, for themselves. They will continue to pay eight or ten dollars a ton for coal that they used to buy for three, because a band of industrial barons had the "thrift, enterprise and industry" to acquire most of the workable deposits and dominate the transportation and distribution of mined coal.

Is this process to be repeated with the water powers?

With the increasing price of fuel, both coal and oil, and especially with the electrical development which makes their power transmissible to points of application remote from its source, the value of water powers is increasing by leaps and bounds. The increasing uses of power for interurban trolleys, farm work, outlying industries, to say nothing of the growing urban demands, promise a rapid absorption of the power available in our rivers as it is developed.

What are to be the conditions of this development?

It is desirable that they should be developed, if the people are thereby put in the enjoyment of light and power at a decreased cost. Otherwise they had better remain in the people's hands as an available asset against the time when they are driven to the conviction that they can do things on their own account.

The water rights of most of these rivers remaining still in the hands of the people and cheap power being one of the most desirable and beneficient things that a people can have, it would seem to be the natural and logical thing for the people in their collective capacity, that is the government, which is of the people, to develop them and to furnish electrical energy to themselves at cost, and if this is to be done at cost it would not seem to matter materially whether the development and administration were undertaken by the federal government or that of the state in which the site were located, except as to the control of patronage.

If the power privileges are to be conceded to private interests which will undertake their development only with the obvious purpose of making money out of it the fact should not be lost sight of that the money made will come out of the users of the power; and provision should be made that this should not exceed a generous but fair profit upon the capital actually invested. There is no sense in giving a water power away that it may be developed and power from it sold at a price which will just compete with steam-made power when by the exercise of a legitimate governmental activity the people can be put into perpetual enjoyment of that power at the cost of its production.

At the recent conservation congress, Gifford Pinchot declared that concentration in water-power control had doubled in ten years and that the ten leading interests today control sixty-five per cent. of all the developed water powers of the United States. A warp is put into the argument that these concessions must be given to big industrial interests in order that they may be developed at all by the fact that during the past five years the concentration of control by ten large financial groups has increased seven times as fast as the power developed by these groups, and for the past two years their control of undeveloped power has increased twice as fast as that developed by them.

The states' rights issue over which the congress split seems to have been injected by the interests which prefer the diversified and more manageable control of the state legislatures to the potent and unified policy and control of the central government.

Air of Infiltration

Much progress has been made in steam-boiler economy, especially along the lines of automatic stokers, improved grates, baffling, distribution of boiler tubes, circulation within the boiler, flexible draft control, automatic recording apparatus, water treatment, etc. All these have tended to raise the degree of efficiency attained in the generation of steam.

In fact, practically every factor affecting the proper handling of fuel has, with one exception, received careful and more or less constant attention. This is the housing of the apparatus which is expected to absorb the heat energy produced in the furnaces. The boiler setting, the mass of brickwork which surrounds every vital part of the steam-producing apparatus, is built with the primary object of confining the heat and forcing it to come into intimate contact with every part of the apparatus capable of heat absorption. For this reason, the settings are lined with firebrick so that great torrents of heat-laden gases may be forced through the mass of tubes. The heat insulation of the firebrick is increased by an outer coat of heat-resisting common or red brick. In short, considerable effort is made to keep all of the heat energy within the setting.

In most cases, however, but little effort is made to keep the cool air of the boiler room from entering the heat-absorbing apparatus and so reducing the amount of heat available.

How many engineers know whether their plant is running at a lowered efficiency, because of the cooling effect which air (drawn in through the brickwork and around poorly hung clean-out doors, etc.) exerts upon the heat-absorbing surfaces?

How many are supplied with the proper apparatus for carrying out simple tests, to satisfy themselves that this loss is minimum or of such magnitude that they cannot well afford to let it continue?

The air from the boiler room, drawn into the setting of boilers by the action of the reduced pressure within these settings, is commonly called air of infiltration, because, as the name implies, it is generally admitted through the settings by a process of seepage following the fine interstices in the bricks, the joints between the bricks, and around clean-out doors, and door frames, etc. It is only through tests that its presence can be known, and it is well worth while to make these tests from time to time as the article on page 72 very forcibly shows.

The settings must be watched, frequent tests made and, when required, a general overhauling given because in most plants the settings are subjected to temperature changes which are likely to work havoc with the best of brickwork. This is especially true in plants where much banking of fires is essential, such as railway power stations, during periods of base load. At the expiration of the base-load periods and just preceding peak loads, the banked fires are raised to full intensity in the shortest possible time. Such severe changes cause more damage to the average setting than long periods of running at full intensity of fires but at an almost uniform temperature.

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Boiler Settings and Efficiency

To obtain good operating results the equipment must be of proper design to start with. It would not be reasonable to expect 80 per cent. efficiency from a boiler unit designed for anthracite coal but fired with bituminous. Yet, it would be astonishing to learn the number of misfit boiler installations that have been and are being placed in service, often on the recommendation of men who should know better.

Much of this misapplication is caused by human conservatism, unwillingness to change the ancient order of things. A company puts in a boiler of a certain type and set in a certain manner, usually conventional, in its Eastern plant and secures satisfactory results. Later, it establishes a Western branch and, often, the man with the buying authority, be he the owner, the consulting engineer or the operating engineer, confidently orders equipment as nearly as possible in duplication of that in the Eastern establishment. The plant in the East made good, he sees no reason why the new one in the West will not.

The makers of apparatus themselves sometimes make the similar mistake of recommending something that has proved successful elsewhere for conditions that are not at all the same.

The designing of a boiler plant involves many factors. Laying out the setting alone is a study and almost each installation is a law unto itself. The character of the duty required and the fuel to be employed are the fundamental considerations. These should determine the kind of grate and firing to employ—manual or mechanical stoking. High rates of driving and high load factors usually indicate automatic stokers. In some localities, labor conditions and cost may be important. The cost of coal has its influence. When the method of stoking has been selected the type of grate or stoker must be determined upon. Here, further study is required, because numerous distinct types all possess some merit, yet probably only one is best suited to the case in hand.

Next, will come the type and dimensions of the furnace, then, the gas passages and the baffling. On these points, authorities that otherwise agree, are prone to differ greatly. In many quarters the combustion arch—so long regarded as the panacea for the smoke evil in the burning of soft coal—is now falling into discredit. Latest thought indicates that the draft is the thing. And so, they are reducing the size of the furnace arch, and moving it toward the rear of the setting, simplifying and amplifying parts of the gas channel and insisting that adequate draft capacity be provided. Results have indicated that such changes are often beneficial. The change in arch location and design, at least, results in reduced cost of maintenance.

The practice with regard to baffles has also seen change recently. It is still more or less orthodox to compel the gases to follow a tortuous path by baffling, on the theory that only great linear contact at high speed is conducive to economy. The exact effect of velocity on the efficiency and rate of heat transmission is still far from being well understood. It would seem that there is one velocity, probably neither the highest nor lowest practicable, at which efficiency is maximum for any given installation. This velocity is probably different for different operating conditions and must be obtained by proper baffling and draft adjustment for the individual case. A standard baffle practice for all applications is not conducive to highest efficiency from the standpoint of design.

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Beginning with this issue of Power, there will be a change in the makeup of the paper, in that subjects along special lines will not be grouped under departmental headings as heretofore. This does not mean that we intend to slight the electrical, gas-power, refrigerating and heating and ventilating fields, as those of our readers who are specially interested in these branches will find just as much of this material as formerly. A short time ago the two letter departments were consolidated. Now with them will be put all letters formerly found in the various departments, and the heading will be "Correspondence."

Both of these changes affect the arrangement only.

*

The result of the inspection of locomotives by the Interstate Commerce Commission, instituted by the Act of Congress of Feb. 17, 1911, is already apparent in reduced injuries and loss of life. In 1912 there were 856 accidents resulting from failures of locomotive boilers and their appurtenances, causing 91 deaths and injuring 1005 persons.

In 1913 these items were reduced to 820 accidents, 36 deaths and 911 injuries. Of 90,346 locomotives inspected, over half (54,522) were found to be defective, and 6690 were either held out of service or ordered changed and strengthened to conform to the requirements of the law. It is difficult to understand the attitude of certain railroad officials who object to making some of the repairs and revisions called for, although the defects are such as might cause serious accident, on the ground that the law does not cover such defects and that the commission was exceeding its authority in pointing them out and calling for their correction.

Correspondence

Convex Boiler Heads

A recent disastrous boiler explosion, and several similar accidents, where the cause of the trouble was ascribed to so called breathing action in the turn of the flange of convex drum heads, point to the necessity of greater care in designing these heads. The usual way of determining the strength of these heads is to consider them part of a sphere, according to the formula:

$$P = \frac{t \times T.S.}{\frac{1}{2} R \times F}$$

in which

P = Allowable pressure;
t = Thickness of plate in inches;
$T.S.$ = Tensile strength of material in pounds per square inch;
R = Radius of curvature;
F = Factor of safety.

The different state boiler laws that have made their appearance of late years stipulate a minimum factor of safety of five to be used in connection with the foregoing formula for convex heads without manholes, which would seem ample, although it is quite common to find the factor of safety greater than five on the heads at the allowable pressure as determined from the strength of other parts of the same boiler.

It would appear from past behavior of these heads that some important factor in their design has in cases received rather scant attention, and this in the writer's opinion is the radius at which the flanges are turned over.

With some exceptions, it is practically an established practice to bump the heads to a radius equal to the diameter of the drum on which the heads are to serve. No such uniformity of practice appears to exist in regard to the radius of the turn of the flange. This radius one may find to range anywhere between the equivalent of five or more times the thickness of the plate to almost nothing, or what practically amounts to a sharp corner.

It is obvious that there ought to be a reasonably good ratio for this radius in relation to the thickness of plate and the radius of curvature of the heads. In analyzing the character of the strains that are to be anticipated, one may expect, as is seen from Fig. 1, that the drum head when subjected to internal pressure tends to assume the shape of a true half sphere as in the dotted lines, which would be the ideal form of convex head and in which the strains due to internal pressure would be uniformly distributed.

In reality the convex head actually does flex outward, Fig. 2, though to a very small extent. The part that has to bear the brunt of this flexing is the heel of the flange. It follows that the smaller the radius at which the heel of the flange is turned over, the more localized will be the strains at one point (Fig. 2), and the construction becomes inferior to that of a well braced flat head. The result is, that after a long period of repeated straining and subsequent relaxing, the metal begins to crack.

Corrosion will naturally be most active on the clean metal thus exposed in the cracks and aids materially in weakening the sheet, which eventually may rupture.

Thus it will be seen, that the true factor of safety on this form of head is likely to be a very uncertain value, if the turn of the flange is not a sufficiently gradual one, and a factor of safety of five in connection with the thickness of the head may not be sufficient to take care of structural weakness due to too sharp a turn of the flange.

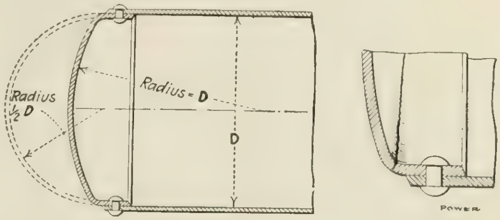

FIG. 1 FIG. 2

SHOWING TENDENCY OF HEAD TO ASSUME SPHERICAL SHAPE AND SECTION WHERE CRACKS ARE MOST LIKELY TO OCCUR

The establishing of a minimum radius, say, of not less than five times the thickness of plate, undoubtedly would prove of benefit in the prevention of explosions.

Hartford, Conn. H. J. VANDER EB.

[The contention that the weak point is the turn of the flange, is borne out by the diagram of the stresses in a boiler drum, on page 50.—EDITOR.]

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Spheres and Convex Heads

In considering the strength of a thin hollow sphere, to resist internal pressure, the simplest method is to divide the vessel into two equal parts, or hemispheres. Bearing in mind the laws relating to thin hollow cylinders, consider the ends to be truly spherical. By such procedure we find the unit stress on such ends, heads or hemispheres, to be one-half that on a longitudinal seam of the cylinder. Hence, in calculating the allowable pressure, R the radius is taken at one-half that of the cylinder. On this basis there are two formulas; one to determine the allowable pressure, and the other to find the required thickness for a given pressure; these are as follows:

$$t = \frac{P \times R \times F}{T.S. \times E}$$

$$P = \frac{T.S. \times t \times E}{R \times F}$$

where R equals one-half the radius of the sphere; t, the thickness of the plate; $T.S.$, the tensile strength in pounds per square inch; F, the factor of safety, usually 5; and E, the efficiency of the riveted seam.

Such rules are used in practice for spherical vessels, notably in straw-board mills, which are often built up to 14 ft. in diameter.

Applying the foregoing to convex heads, for steam boilers, the rules declare the head should be bumped or convexed to a radius equal to the diameter of the drum or cylinder of which it forms an end. At present the rules pertaining to such heads are those of the U. S. Government, and the states of Massachusetts and Ohio. By the government rules where P is the pressure allowed; R, one half the radius to which the head is convexed; t, the thickness of plate and S, one fifth the tensile strength,

$$P = \frac{t \times S}{R}$$

The Massachusetts rule using the same constants, except taking $T.S.$ at full value and using an apparent factor of safety of 5, is as follows:

$$t = \frac{R \times 5 \times P}{T.S.}$$

By the former the inspector finds the allowable pressure, and by the latter the designer is presumed to find the thickness required. In each the factor of safety is presumed to be five. Comparing these with the rules pertaining to a sphere, it is noted that no value, other than contained in the factor of safety, is taken as respects the efficiency of the seam for the head. Indeed, were the seam double-riveted no more pressure would be allowed, although the strength of the seam would be greatly increased. Inasmuch as these rules are based on the laws of spheres, there exists no good reason why the efficiency of the seam should not have been considered in formulating ways to determine P and t just as in spherical rotary vessels.

But, as a matter of fact, convex heads are spherical only at certain points, and therefore such rules are far from correct. In practice the head must diverge from spherical form where it bends to enter the cylinder, at the point, termed in practice, the heel of the flange, and this point is from 3 to 6 in. from the center of the rivets. In the sphere the laws depend upon the vessel being truly spherical, and in the cylinder as being truly cylindrical, so also as regards convex heads, if we are seeking exactness. It is contended by some that flexure or bending action occurs with variations of pressure in the circular zone at or near the heel of the flange where the spherical lines terminate. Certainly, it is an error to assume that this section is spherical and governed by the laws of a sphere as respects internal pressure.

It is more than a mere coincidence that two recent explosions are on record wherein the initial ruptures occurred by failures of convex heads in the zone referred to. In the first case a Climax boiler exploded in Brooklyn a few years ago. The dimensions as respects the shell, head and pressure were as follows: Diameter of shell, 48 in.; steam pressure, 150 lb. (adding 10 lb. for water head = 160 lb.); original thickness of bottom head, ¾ in. The external side of the head was badly wasted away and the thickness at the point of fracture was about 0.33 in. The diameter of opening was about 41 in. In the second instance a Wickes vertical boiler on Staten Island exploded by reason of a circular section of the bottom convex head failing, tearing out a section of about 80 in. diameter; see POWER, Nov. 4, for details. The data of the latter are as follows: Diameter lower drum, 90 in.; pressure carried, 150 lb. (adding 10 lb. for water head = 160 lb. total). In this case internal corrosion had wasted away the plate to some extent. In the main, the thickness was reduced to 9/16 in., and, at one section of fracture, to about ½ in. This was measured only at the ring remaining of the head that failed, the other section not being available. Several experts, however, coincide in the measurements being approximately correct in each case.

It is worth while to compare the data submitted with the existing rules, or, rather, laws, for convex heads. Taking the Climax boiler with $t = 0.33$ in., we have, using 60,000-lb. T.S.

$$\frac{0.333 \times 12{,}000}{24} = 166 \textit{ lb. allowable pressure}$$

and with the Wickes head, and same tensile strength

$$\frac{0.5 \times 12{,}000}{45} = 133 \textit{ lb.}$$

The apparent factor of safety in each is 5; hence, the calculated bursting pressure $166 \times 5 = 830$ lb. with the Climax, and with the Wickes, $133 \times 5 = 665$ lb., whereas the heads failed at, or very nearly, the pressures stated above. Evidently the metal, even at the reduced thickness was in a weakened condition or small annular cracks were present as a result of the continued flexure. It seems therefore these two explosions graphically show the true bursting pressure of such heads, and that the factor of safety as given in the rules is a dangerous fallacy.

In the case of the Wickes boiler, it is evident the designer was strictly within the U. S. Government rules, for, with ¾-in. head, 60,000-lb. tensile strength and a diameter of 90 in., we have

$$\frac{0.75 \times 12{,}000}{45} = 200 \textit{ lb. allowable pressure}$$

One would inquire, however, if ¾ in. is ample for a 90-in. head for 200 lb.; also, why the builders of the Climax boiler used the same thickness for a 48-in. head without a manhead. According to the rule, it would have been safe with an apparent factor of safety of 5, using 60,000-lb. tensile strength and 200 lb. pressure, as follows:

$$\frac{24 \times 5 \times 200}{60{,}000} = 0.4 \textit{ inch}$$

or but little more than the thickness at the point of rupture.

Comparing the pressure allowable by the rules with the actual bursting pressures, it appears the real factor of safety is far below what it should be.

Digressing to inquire further concerning these explosions it has been said that water-hammer may have been the cause; that, owing to the vertical design, were the water lifted, and then, in return, projected violently on the bottom head this would have caused or accounted for the explosions. With regard to this feature, so far as could be learned from all available sources, the boilers were in actual service for some time prior to the explosions and hence the conjecture was not borne out nor proved. That convex heads in vertical boilers would be peculiarly weak in this respect is true, and it follows that this feature should be considered in designing such boilers. The 48-in. shell, with ¾-in. head, is conceded to have met such requirements, but, unfortunately, neglected to provide facilities for examination of the head on the outside, and this inaccessible section wasted and rotted away. In regard to the Wickes head, it has been said the initial rupture took place at the point of fracture where corrosion was greatest and then tore completely around the circle, charging the failure to the thin section alone. In the writer's opinion this would not have been the case for, with merely local weakness at one point, and opening by reason of sheer weakness, would have been similar exactly to the rupture of a bag on the fire-sheet of a horizontal tubular boiler, and, hence, would not have extended in a circular manner for a distance of about 250 in. unless the metal was already greatly weakened by flexure. Of course, in this head, braces were attached for the purpose of assisting the tubes in supporting the flat tube sheet, as the central tubes in this type of boiler are in compression, and the ones nearest the flange in tension. These braces had given trouble; one was broken at the heel. The writer did not, however, consider the braces as a direct cause for, evidently, such was not the case. That corrosion was a contributory cause is, of course, true in each instance.

Returning to the question of the laws pertaining to convex heads it is well known that most builders using convex heads in drums provide much heavier ones than required by the laws, as, indeed, was the case in the Climax boiler. The rule used by such builders may be based on experiments made on such heads, or may be based on good judgment gained in years of actual practice. It is to their credit that they have provided heads far heavier than required by the law; that they have acted on convictions to protect the buyer.

To deduce a better rule than the present laws, it has been necessary merely to measure what is the best practice of today, and this is as follows:

Let
P = Steam pressure allowable;
t = Thickness of plate in inches;
$T.S.$ = Tensile strength (not more than 56,000 lb.);
F = Factor of safety ($8\frac{1}{3}$);
R = One-half the radius to which the head is convexed, the radius to be not less than the diameter of the drum.

With this data, and for heads without manholes, we have

$$P = \frac{t \times T.S.}{R \times 8.33}$$

$$t = \frac{R \times 8.33 \times P}{T.S.}$$

The results obtained by the proposed rule are:

42 in. diameter and 200 lb. pressure, t = 0.625 in.
48 in. diameter and 200 lb. pressure, t = 0.714 in.
90 in. diameter and 200 lb. pressure, t = 1.338 in.

By the U. S. Government, Massachusetts and Ohio rules we have:

42 in. diameter and 200 lb. pressure, t = 0.375 in.
48 in. diameter and 200 lb. pressure, t = 0.4286 in.
90 in. diameter and 200 lb. pressure, t = 0.803 in.

In the foregoing the tensile strength is taken at 56,000 lb. for the reason that mild steel with low carbon content is better material for this purpose than higher carbon steel. Ductility is essential for long life and is perhaps less susceptible to corrosion.

The weakness of the present laws as proved by the heavier heads used, together with evidences obtained from the two explosions, should result in revising the laws about on the lines given above. It is to be noted that in each of these explosions seven lives were lost, and, in addition, several persons were injured, together with heavy property damages. It does not appear proper that this be deferred pending further evidence in the way of disastrous explosions, that is, if we are really desirous of the safety for which ostensibly steam-boiler laws were created. Pending some action to this end, may I suggest the above be carefully considered by the operating engineer and managers of plants, for, possibly, under their care may be badly corroded heads similar to the ones that failed in the cases referred to.

T. T. Parker.

New York City.

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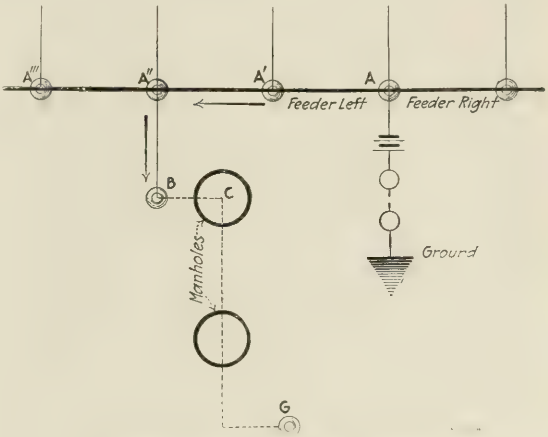
Pocket Compass for Locating Ground

I was once assigned the duty of locating a dead ground upon a 220-volt lighting system, and while the ammeter method as outlined by "Foster's Electrical Engineers' Handbook" could have been employed, a more novel method was resorted to. In the diagram one side of the circuit only is shown, A, A', etc., representing tops of poles from which service wires are tapped from feeders; B is the top of a pole from which the feeders change from aërial to underground lead-covered cable by way of manhole C.

The main generator switch being opened, the positive side of a storage battery, the leads of which were available at various points of the system, was connected at A'; the negative side being grounded through a bank of lamps.



Location of Poles and Feeders

As the poles were stepped it was an easy matter to climb them and with a compass determine which path the current was taking to the ground, thence back to the battery. Ascending the pole A' and placing the compass over the feeder to the right, it was not affected, but when placed over the feeder to the left it was affected in the usual way, thus indicating a flow of current. Ascending the poles in order it was observed that the current was confining itself to the feeder as indicated by the arrow. As manhole C was entered, the compass was not affected so strongly by any one conductor, but feebly by several or by their sheaths. This action led to the belief that the bad conductor to which the positive side of the battery was connected was grounded between the top of the pole and the manhole.

To verify this conclusion, the connection at A' was changed to G and pole B was climbed again, from which it was observed that no appreciable current flowed into any of the aerial leads. Manhole C was again entered and here is where I was nonplussed for a few minutes, because the compass pointed in the opposite direction to that which might have been expected. It suddenly dawned upon me that the lead might be grounded to its own sheath, and in such a case, it having been decided that the lead was grounded between the manhole and the top of the pole, nearly all of the current would return through the sheath. Since the conductor was concentric, we should expect the two fields to neutralize each other beyond the detection of a compass of the pocket variety. But in this case the field set up by the current returning through the lead sheath influenced the compass, but, of course, quite feebly as compared with its unneutralized effect.

When starting out to locate the ground I had expected that the dead ground was the outgrowth of some incipient fault in the old work, some new extensions to the system nearing completion not being in the least suspected. But it proved, however, that the fault was in the new cable where it had been spliced onto the aërial line. The lead sheath had not been stripped back far enough and where the underground cable was soldered to the aërial cable the solder had run and connected solidly from copper to sheath.

Amos J. Carr.

Cape Cottage, Maine.

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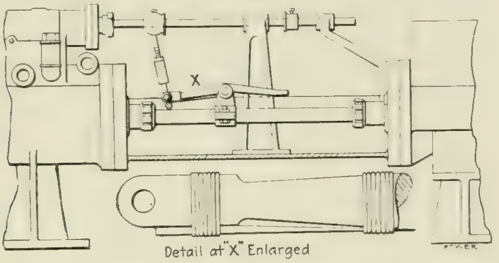
Emergency Repair to Feed Pump

Sometime ago I went to work in a factory as night engineer. As the chief showed me around he mentioned, among other things, that there was only one feed pump available, the other one, a single, double-acting pump, having been out of service for the last two years and was considered beyond repair, but would be replaced by a new one in the near future.

As luck would have it, the good pump broke down in the early part of the night. Taking the chief's word that the other pump was beyond repair, I told the foreman that we would have to shut down. He said that if we did, it would mean a big loss to the company.



How the Wedge Was Applied

I then decided to try the old pump. It refused to go more than one stroke. There was the possibility, however, of keeping it going if somebody stood by and worked the rocking lever.

I made several adjustments to the rocker connection and found that the only trouble was that during years of operation the rocker roller wore down in the diameter to such an extent that it could not lift the rocker at both ends.

I made a quick, emergency repair in a couple of minutes by whittling a piece of wood wedge shape, the thickest end being about 1/8 in., and tied it with two piece of wire to the working face of the rocker, and the pump worked satisfactorily while the other pump was being repaired.

The next day I turned down, in the lathe, another roller of 1/8 in. larger diameter and the pump was as good as new.

Victor Boss.

Washington, D. C.

⁂

Fitting and Failure of Pistons*

I have read with considerable interest the article in the Nov. 18 issue of Power, describing a piston failure in one of the mills at Paterson, N. J.

Why was the piston made a taper fit? This alone invites disaster.

Some years ago, when I followed locomotive work, it was the usual practice to make taper fits on both the crosshead and piston. The piston rod was ground into a perfect fit, then forced to place and keyed. Just why a part like a piston, that will in all probability never be taken off until worn out, should be so fitted is beyond me.

When it came within my province to direct such matters the pistons were fitted straight; in fact, the rod was made a few thousandths large at the end, turned with a medium coarse feed, the piston bored the proper size and shrunk on. With this method the ridges on the steel rod sink into the warm cast iron and make absolute contact, impossible to separate in ordinary service. The rod was then riveted over. I have used this practice on pistons up to 44 in. in diameter and never had a failure.

Some years ago a piston failed on a comparatively new engine. A crack being discovered a new piston was furnished by the builders. When received the piston was entirely finished except the bore, which was left below sizes for fitting. Feeling perfectly confident of a successful outcome, the defective piston was broken off, the rod trued as stated above and the piston bored to a shrink fit. The work was done by a very able workman, but I took the precaution to caliper the fit and decided the bore was too large. Another workman was called and he, like number one, decided the fit was all right. The piston was shrunk on and pronounced a good job.

They were then told to put the piston in the hydraulic press and see what pressure could be applied without starting the rod. Here, again, I was held up, as the jaw of the press was not large enough for the piston rod. I ordered the jaw chipped out, and started the rod with about six tons pressure. As the piston was nearly 30 in. in diameter a wrecked engine would have been the result. The engine had to be ready for service the following morning; and as no material was to be had for a new rod, and with the defective piston broken up, I was in a very uncomfortable position.

However, a thin steel liner was rolled to exact size of the piston bore, the piston again fitted and shrunk on the rod over the liner in the usual way, and again placed in the hydraulic press. Thirty tons failed to start the rod this time. The rod was riveted over and the engine put in service, and so far as I know, is still running and giving no trouble.

Los Angeles, Calif. H. P. Clarke.

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*"Power," Nov. 18, pp. 735 and 725.

Inquiries of General Interest

Heat Value of Natural Gas—What is the heat value of natural gas per 1000 cu.ft.?

V. K. S.

The calorific value of natural gas varies in different localities from about 1,100,000 B.t.u. to about 842,000 B.t.u. per 1000 cu.ft.

Height for Glass Gage on a Return-Tubular Boiler—At what height should the glass water-gage be set on a horizontal return-tubular boiler?

W. H.

So the lowest visible part of the glass will be at least 2 in. higher than the top of any tube of the boiler.

Pulsometer Trouble—Why should a pulsometer pump refuse to lift water excepting when the pump is submerged?

G. M.

The refusal of the pulsometer to operate unless submerged is probably due to leakage of the valves. The pump should be cleared of obstructions and the valves should be inspected and made tight.

Auxiliary Heating Surface—What is the usual method of adding pipe coil heating surface to a return-tubular boiler?

J. L. G.

Such auxiliary heating surface is usually added by placing pipe coils along the sides of the furnace walls and connecting them to both the front and rear ends of the boiler to insure more active circulation.

Rating of Feed Water Heaters—How many square feet of heating surface are allowed per horsepower for closed feed-water heaters?

M. S.

For commercial purposes, closed exhaust steam feed-water heaters are usually given a rating which allows about ⅓ sq.ft. of heating surface per horsepower.

Equivalent Evaporation—What evaporation from and at 212 deg. F. is equivalent to the usual boiler horsepower consisting of the evaporation per hour of 30 lb. of water from a feed-water temperature of 100 deg. F. into steam at 70 lb. gage pressure?

P. R.

Evaporation of about 34.48 lb. of water per hr. from and at 212 deg. F. would be equivalent to one boiler horsepower, but for ordinary calculations an evaporation of 34½ lb. of water from and at 212 deg. F. per hr. is usually taken as the equivalent.

Blowing Off Boiler Direct Into Sewer—What are the objections to connecting steam drips into a sewer or to blowing off a boiler directly into a pipe sewer?

J. G.

Most kinds of earthenware sewer pipes are rapidly disintegrated by the action of steam and hot water, and when a sewer pipe is connected with plumbing fixtures by iron piping, the latter is rapidly rusted away by the presence of steam and the back pressure due to blowing off causes disagreeable and unhealthy sewage vapors to arise from the plumbing fixtures.

Steel Steam Fittings—What is the difference between cast steel and the material of which steel steam fittings are made?

W. F. M.

The cast steel of fine grain such as was formerly used for the best cutlery, etc., is made by adding carbon to molten iron, after which treatment, the material is cast into billets and worked up into form by rolling and forging. Steel steam fittings are usually made by melting bessemer, openhearth or other kinds of steel and casting the molten metal in molds the same as in the manufacture of ordinary iron castings from molten cast iron.

Velocity of Entering Air—What is the maximum velocity at which air from a heating or ventilating system should enter a room? What are the reasons for such limitations of velocity?

M. N.

The velocity of air entering a room should not exceed 4 to 6 ft. per sec. unless the air can be so introduced as to make an insensible current. This is for the reason that higher velocities produce disagreeable currents, generally known as drafts, more or less dangerous to health and less efficient for purposes of heating or ventilating.

Wear of Steam Hose—What is the reason that for some uses a steam hose out of the same lot as another will develop leaks more rapidly when used for the same pressure and temperature of steam, and what is the remedy?

B. F. G.

The less durable hose is undoubtedly subjected to greater mechanical abuse, the commonest being to draw the hose out from a circular coil, causing twists and kinks. Twisting will not occur in drawing out the hose from a reel or when it has been hung up on two pegs by reeving the hose over the pegs in form of the figure 8 laid on its side.

Loss by Radiation from Covered Pipe—What loss of heat would occur by radiation from a 3-in. steam pipe 500 ft. long filled with steam at 338 deg. F., surrounded by atmospheric air at 80 deg. F. and covered with ordinarily good nonconducting covering?

G. D.

The bare pipe would have a surface of about

$$500 \div 1.09 = \text{about } 458 \text{ sq.ft.}$$

and the difference between the temperatures inside the pipe and of the external air would be

$$338 - 80 = 258 \text{ deg. F.}$$

The loss by radiation would be about 0.5 B.t.u. per sq.ft. of pipe per hour per degree difference, so that the total loss by radiation would be approximately

$$458 \times 258 \times 0.5 \quad 59{,}082 \text{ B.t.u. per hr.}$$

Factor of Evaporation—Having feed-water temperature at 50 deg. F. and evaporation at 100 lb. pressure per sq.in., absolute, what would be the factor of evaporation?

A. J. D. F.

From the "Marks and Davis Steam Tables," it is to be seen that to raise a pound of water from 32 deg. F. into steam at 100 lb. per sq.in., absolute, requires 1186.3 heat units (B.t.u.). With feed water at 50 deg. F., each pound of water raised into steam at a pressure of 100 lb., absolute, would receive 1186.3 — (50-32) = 1186.3 — 18 = 1168.3 B.t.u. To evaporate one pound of water from 212 deg. F. into steam at 212—i.e., at atmospheric pressure, or as commonly stated, from at 212 deg. F., requires for latent heat of evaporation 970.4 heat units. Hence, with feed water at 50 deg. F. and evaporation at 100 lb. pressure absolute, the factor of evaporation is

$$\frac{1168.3}{970.4} \quad 1.2039$$

Head Required for Water Pipe Line—What difference of head would be required to discharge 600 gal. of water per min. from one tank to another through a 7-in. galvanized iron pipe 2500 ft. long?

O. S. C.

The velocity would be practically 5 ft. per sec. Referring to tables given on page 55, July 9, 1912 issue, of "Power," the loss of head per hundred feet of 7-in. iron pipe due to discharging water at the rate of 5 ft. per sec. may be found to be about 1.47 ft., and for 2500 ft. of pipe it would be

$$\frac{1.47 \times 2500}{100} = 36.75 \text{ ft. loss of head.}$$

Flowing at the rate of 5 ft. per sec. would require a velocity head of about 0.39 ft., and assuming, as usual, that the loss of head due to friction at the entrance would be equal to one-half the velocity head—i.e., ½ of 0.39 = 0.19 ft.—then it is seen that the total difference of head required would be

$$36.75 + 0.39 + 0.19 = 37.33 \text{ ft.,}$$

or 37 ft. 4 in.

Engineers' Study Course

Trigonometry--VIII

LAST LESSON'S ANSWERS

31. In the solution of all right triangles it is a help to keep in mind the typical triangle (Fig. 2, Lesson I; reproduced herewith as Fig. 7). The lettering can be easily remembered by noticing that the side *b* is the *base* and the side *a* the *a*ltitude. Then *c* is the only side left (the hypotenuse) and the angles have the same letters (but capitals) as the sides opposite them. The functions can then be remembered by the shorter forms given in Lesson I (as $sin\ A = \frac{a}{c}$) more readily than by those given in the last lesson (as $sine = \frac{opposite\ side}{hypotenuse}$).

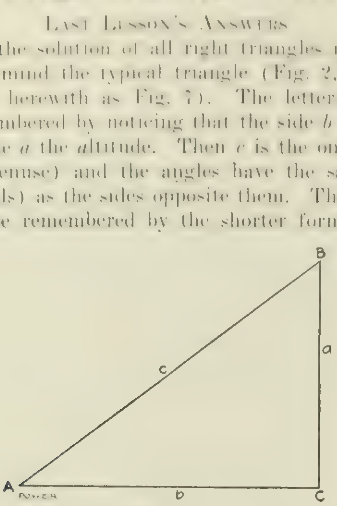

FIG. 7

Given $sin\ A = \frac{1}{2}$ and $c = 36$ in. Since $sin\ A = \frac{a}{c}$.

$$\tfrac{1}{2} = \frac{a}{36\ in.}\ or\ a = 18\ in.$$

and the third side

$$b = \sqrt{c^2 - a^2} = \sqrt{36^2 - 18^2} = 31.177\ in.$$

The sine of the other oblique angle will be its opposite side divided by the hypotenuse, or the same as the cosine of A, or

$$sin\ B = cos\ A = \frac{b}{c} = \frac{31.177}{36} = 0.866$$

As a check, refer to the table in Lesson II. It will be found that the acute angle whose sine is ½ is 30 deg. Therefore, the other acute angle must be 90 — 30 = 60 deg. and, from the table, *sin* 60 deg. = 0.866.

32. Given the base ($b = 20$) and the altitude ($a = 32$). The hypotenuse (c) will be

$$c = \sqrt{a^2 + b^2} = \sqrt{32^2 + 20^2} = 37.736$$

$$sin\ A = \frac{a}{c} = \frac{32}{37.736} = 0.848$$

From the table (Lesson II) the angle corresponding to this sine is 58 deg. The other acute anglę is thereforc

$$90 - 58 = 32\ deg.$$

33. Given $c = 235$ and $A = 43$ deg. The other acute angle will be

$$B = 90 - 43 = 47\ deg.$$

From the table $sin\ A = 0.682$. Then, since $sin\ A = \frac{a}{c}$,

$$0.682 = \frac{a}{235},\quad a = 0.682 \times 235 = 160.27$$

From the table $sin\ B$ (or $cos\ A$) = 0.7314. Then, since $cos\ A = \frac{b}{c}$,

$$0.7314 = \frac{b}{235},\quad b = 0.7314 \times 235 = 171.879$$

If it is desired to check the work, it can be seen if the sides agree in the relation

$$c^2 = a^2 + b^2$$

The method used in the solution of this problem suggests two rules for similar ones:

Given the hypotenuse and one angle of a right triangle, to find the opposite side, multiply the sine of the angle by the hypotenuse, and, to find the adjacent side, multiply the cosine of the angle by the hypotenuse.

34. Given $A = 47$ deg., and $b = 180$ ft. From the table *cos* 47 deg. = 0.682. Since $cos\ A = \frac{b}{c}$.

$$0.682 = \frac{180}{c},\quad c = \frac{180}{0.682} = 263.93\ ft.$$

From the table *sin* 47 deg = 0.7314. Then, applying the rule just given,

$$a = sin\ A \times c = 0.7314 \times 263.93 = 193.04\ ft. = height\ of\ chimney$$

35. In effect the problem states that the connecting-rod (the hypotenuse c) is 1½ in. longer than the distance from the center of the crosshead pin to the center of the crankshaft (the base b).

Given, then, $a = 8$ in. and $b = c - 1\frac{1}{2}$ in. Also $b = \sqrt{c^2 - a^2} = \sqrt{c^2 - 64}$.

Then

$$c - 1\tfrac{1}{2} = \sqrt{c^2 - 64}$$

Squaring both sides

$$c^2 - 3c + \tfrac{9}{4} = c^2 - 64$$

Canceling c^2 and transposing

$$64 + \tfrac{9}{4} = 3c \quad 3c = \tfrac{265}{4} \quad c = \tfrac{265}{12} = 22.08\ in.$$

Required angle A. Since $sin\ A = \frac{a}{c}$,

$$sin\ A = \frac{8}{22.08} = 0.3623$$

From the table, A is between 21 and 22 deg., for *sin* 21 deg. = 0.3584 and *sin* 22 deg. = 0.3746.

The total difference between the sines of these two angles is

$$0.3746 - 0.3584 = 0.0162$$

The difference between the smaller and the calculated $sin\ A$ is

$$0.3623 - 0.3584 = 0.0039$$

Therefore, the angle A exceeds 21 deg. by about $\frac{0.0039}{0.0162}$, or approximately ¼ deg. A reference to a table of natural functions with greater subdivision of angles would show that the angle A is very closely 21¼ deg., or 21 deg. 15 min., nearly.

SOLUTION OF OBLIQUE TRIANGLES

As distinguished from right triangles, all other triangles are known as *oblique triangles*.

It was stated in Lesson I that "if any three of the six parts (the three angles and the three sides) of a triangle are known, and at least one of them is a side, the shape and size of the triangle are determined." If one were given three such parts one could construct the triangle and measure the unknown parts with a protractor for the angles and a scale for the sides. It remains to be shown how the unknown parts can be calculated from the known without any direct measurements.

As for the angles, when two are known, the third can be found at once by subtracting the sum of the two known angles from 180 deg., for the three angles of any triangle total 180 deg. Each angle of a triangle is therefore the *supplement* of the sum of the other two, as explained in Lesson II. That this is true of right triangles was shown in the answer to question 10 in Lesson III. To prove that it still holds for any triangle, refer to Fig. 8. *ACDA* and *BCDB* being right triangles the sum of the angles of each totals 180 deg. and the two together 360 deg. Subtracting the two right angles *ADC* and *CDB*, which do not figure in the triangle *ACBA*, and there is left

$$360 - 90 - 90 = 180 \textit{ deg.}$$

Another proof:

Angle *ACD* being the complement of angle *CAD* and *DCB* the complement of *CBD*

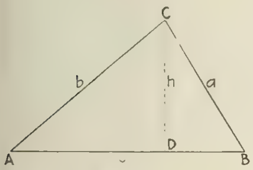

FIG. 8

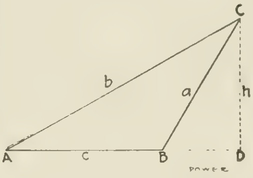

FIG. 9

$$\angle ACD + \angle CAD = 90 \textit{ deg.}$$
$$\angle DCB + \angle CBD = 90 \textit{ deg.}$$

Therefore,

$$\angle ACD + \angle CAD + \angle DCB + \angle CBD = 180 \textit{ deg.}$$

but

$$\angle ACD + \angle DCB = \angle ACB$$

therefore,

$$\angle CAD + \angle ACB + \angle CBD = 180 \textit{ deg.}$$

Either of these proofs would apply to the triangle *ACBA* in Fig. 9 if a perpendicular were drawn from the angle *B* to the side *b*, but the proof may also be made from the figure directly as it is as follows:

$$\angle ACD + \angle CAD = 90 \textit{ deg.}$$
$$\angle BCD + \angle CBD = 90 \textit{ deg.}$$

Therefore,

$$\angle ACD + \angle CAD = \angle BCD + \angle CBD$$

Subtracting $\angle BCD$ from both sides of the equation

$$\angle ACD - \angle BCD + \angle CAD = \angle CBD$$

but

$$\angle ACD - \angle BCD = \angle ACB$$

Therefore,

$$\angle ACB + \angle CAD = \angle CBD$$

Then, since

$$\angle ABC + \angle CBD = 180 \textit{ deg.}$$
$$\angle ABC + \angle ACB + \angle CAD = 180 \textit{ deg.}$$

For the complete solution of any oblique triangle there are four cases which, according to the three known parts, are as follows:

Case I. When one side and two angles are known.

Case II. When two sides and the angle opposite to one of them are known.

Case III. When two sides and the included angle (the angle between them) are known.

Case IV. When the three sides are known.

CASES I AND II

Solutions of triangles having one side and two angles given, or two sides and the angle opposite one of them given, require the use of what is known as *The Law of Sines*, which is stated thus:

The sides of a triangle are proportional to the sines of the opposite angles.

This may be proved by referring to either Fig. 8 or Fig. 9, in both of which *ABCA* represents any triangle, from any angle, as *C*, of which a perpendicular *h* is drawn to the opposite side, or that side extended.

From the right triangle *ACDA*, $h = b \sin A$, and from the right triangle *BCDB*, $h = a \sin B$.

(In Fig. 9 $\sin ABC = \sin CBD$).

Equating the values of h

$$b \sin A = a \sin B$$

which, by transposition, becomes

$$\frac{a}{b} = \frac{\sin A}{\sin B} \qquad (27)$$

In the same way it could be shown that

$$\frac{a}{c} = \frac{\sin A}{\sin C}, \text{ and } \frac{b}{c} = \frac{\sin B}{\sin C}$$

Regarding these three equations as proportions

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

STUDY QUESTIONS

36. Referring to a triangle lettered as in Fig. 8, given $a = 500$, $A = 10$ deg. and $B = 46$ deg., find C, b and c.

37. Given $b = 137.5$ ft., $B = 13$ deg. and $c = 512.5$ ft., determine the other three parts of the triangle.

38. In a triangle lettered as in Fig. 9, given $c = 23$, $A = 23$ deg. and $B = 134$ deg., find a, b and C.

39. To determine the distance across a river between two transmission poles, a distance of 100 ft. along one bank was measured from the base of the near pole and the angles which sights on the distant pole were found to make with the extremities of this line proved to be 45 deg. at the end of the line and 85 deg., at the near pole. What was the distance between the poles?

40. An engine comes to rest beyond the center of a forward stroke. The crank, which is 18 in. long, is at an angle of 45 deg. with the horizontal. The connecting-rod is at what angle with the horizontal, if 45 in. long?

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

ENGINEER WANTED small plant one who is willing to do porter's work. Apply 66 University place.

And then they prate of the dignity of labor! This is a bona fide ad from the New York "World." Now, don't throw up your steady job unless you are sure you can cop this one. The line forms on the right.

⁂

Every now and then a highly peeved party complains that he has asked us to answer an operating inquiry, and he gets highly indignant because we ignore him. Suppose you received a letter signed "A. S. S.," no town name, no street or number, no nothing nohow. There's more than one "A. S. S." in these United States (get me?), so whom would you write to? One week's subscription to the best answer to this inquiry.

⁂

Walter H. Damon, over to Springfield, has sprung into the arena announcing his candidacy for the vice-presidency of the N. A. S. E. There's some spring to Walt, so you other candidates will have to get busy if you hope to make a showing.

⁂

Here's the chance of their lives for the jokesmiths: The Yuba River has been dammed! Yuba dam! Just like that. Nothing ever escapes them, and you may as well be prepared to meet up with this information whichever way you turn.

⁂

The editor of a mining journal has taken his pen in hand to cast contumely on the Finn, who "overbalances his undeniable intelligence and skill with an unextinguishable desire to start something." We see this editor's finish, if ever an irate Finn fastens his fin on him; some Finns are real finnicky.

⁂

It is said that the inventor of the cash register got his inspiration "through close observation of the distance-recording device in the boiler room of an ocean liner." But the other fellows got the fortune, which is the way of most inventors. Whadcha mean, genius is not practical?

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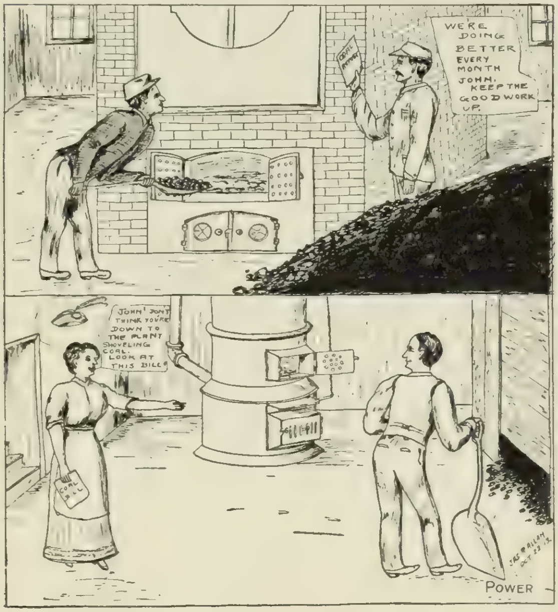
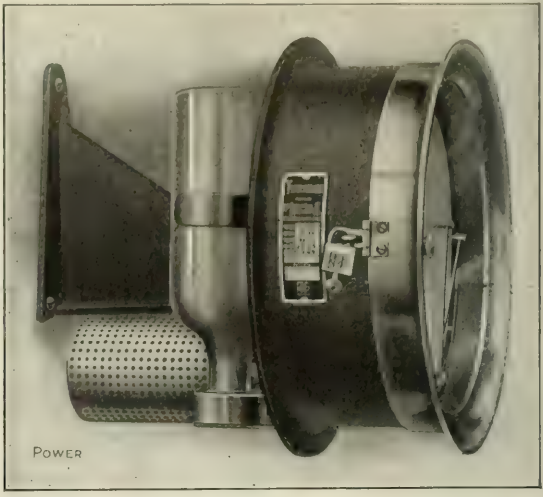

WE'RE DOING BETTER EVERY MONTH JOHN. KEEP THE GOOD WORK UP.
JOHN! DON'T THINK YOU'RE DOWN TO THE PLANT SHOVELING COAL. LOOK AT THIS BILL!
COAL BILL
POWER

"The Fuel Situation"

Improved Recording Hygrometer

The Foxboro hygrometer is, in reality, two instruments in one, a recording thermometer and a wet bulb recorder. The illustration shows the standard form of stationary, self-contained type. It consists of two sensitive bulbs mounted in tandem back of the case, the wet bulb being jacketed and kept moist by maintaining water at a constant level in a trough beneath. The pen arms are attached to shafts concentric with the helical tube bulbs.

The case is mounted on a swivel bracket, enabling swinging the instrument at right angles to the wall or support, giving easy access to the inverted glass bottle serving as the water reservoir. It is made in three sizes, 8, 10 and 12 in., and covers ranges between the freezing point and the boiling point of water. The instrument is made to ascertain the relative humidity in textile manufacturing, etc., by the Industrial Instrument Co., Foxboro, Mass.



Improved Recording Hygrometer

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Elusive Knocks in Ammonia Compressors

By Thomas G. Thurston

Coming into the power house one morning the night engineer informed the writer that the spring on one of the discharge valves of one of the ammonia compressors was broken and that it would be necessary to get a new one. The compressor was a horizontal double-acting machine of 250 tons capacity and the noise it was making gave every indication of a valve slamming on its seat when the spring is broken.

The machine was pumped out and when the bonnet was removed we were surprised to find that the spring was all right. However, to make sure a new spring was put in place. Upon starting up again the noise was as bad as ever and for a while we were at a loss to locate the trouble. Finally, the oiler accidentally solved the problem by drawing up on the stuffing-box nuts to stop a leak at this point. The machine had been in service for several years and the compressor piston rod had been turned down a number of times, so that it was considerably smaller than the hole through the cylinder head. To keep the packing from going through into the cylinder a junk ring had been fitted into the bottom of the stuffing-box and made a snug fit on the rod. It was this junk ring that had been making all the noise. The packing working loose had allowed the ring to move and at the reversal on the crank-end stroke it would strike the bottom of the stuffing-box with a slam, identical to that of a discharge valve with a broken spring.

Coming on duty one morning a couple of weeks later the night engineer had another case of a broken discharge-valve spring. This time it was on a 200-ton vertical machine, and, according to the night engineer, it was one of the top discharge valves. There was a sharp knock and upon standing on the platform beside the cylinder it seemed to be in every place in which we tried to locate it. The conclusion was finally reached that it was in the lower suction valve and the machine was pumped out and the valve cage removed. The valve was all right, but again to make sure a new one was put in place. The knock was still evident when the machine was started up again so the same performance was repeated on the top suction valve with the same result. The bottom discharge valve was tried and when the machine was started the knock was worse than ever.

Finally the top head was removed and the top discharge valves examined. One of them showed a tendency to stick and naturally we thought that the trouble had been located. Upon starting up the knock was as loud as ever. It came after the crank was well past the center and was surely some place in the cylinder, but where was the question. Several brilliant suggestions were advanced by the members of the engine-room force and a number of methods tried to locate the knock without success. I finally went below the cylinder and here the knock was more pronounced and seemed to come from the stuffing-box where it could be felt distinctly. The machine was again pumped out and the first half of the packing removed. The oil lantern stuck to the rod, but we finally got it down. At some time the rod had become too hot and the babbitt in the lantern had softened and when it cooled it had wedged on the rod. When the lantern had been lowered the cause of the trouble was evident. There was no packing back of the lantern and as it stuck to the rod it banged against the bottom of the box at every upstroke of the piston rod. The rod was packed in short order and the trouble was over.

Inspecting a Return-Tubular Boiler, Part I

By James F. Hobart

SYNOPSIS—Information as to how an inspector's suit should be made, what tools are necessary, details to observe and some of the defects expected to be found.

*

Steam-boiler inspection is for the purpose of detecting defects which might lead to possible accident. There are two classes of boiler inspection, that when the structural details are known, and that of unknown boilers. Before an intelligent inspection of an unknown boiler can be made a data sheet must be made out from which calculations of the strength of riveted seams may be determined, also the strength of the braces and stays, and the unsupported areas which are not measured and listed.

When the structural details are known, the boiler should be examined thoroughly, both inside and out, if the shell is large enough to admit of internal inspection. If it is a small vertical boiler then an external inspection and an examination through the several openings in the boiler shell must answer.

First of all a boiler shell should be thoroughly cleaned on the outside by sweeping off all accumulated soot and ashes. It is impossible to properly inspect a boiler when coated with soot and ashes, or when crawling around knee deep in combustion-chamber ashes.

For internal inspection a return-tubular boiler should first be thoroughly washed out and allowed to become reasonably cool by removing the handhole and manhole plates, opening the doors in front of the tubes, and adjusting the dampers and furnace doors so that cold air will be drawn into and through the boiler as well as around it. This will do no harm after the shell has cooled down to 212 deg.

Inspector's Kit

A complete dust-proof suit will help make the task of inspecting a boiler more agreeable. It usually consists of a union suit of overalls and jacket, made to fit closely around the throat, wrist and ankles. A cap fits tightly around the face so that dust and dirt will not work into the hair. Fig. 1 will give an idea of the manner in which an inspector's hood is made.

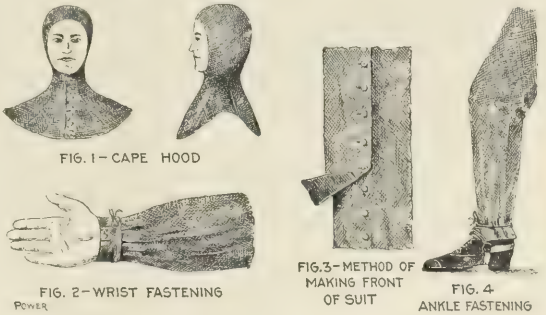


FIG. 1—CAPE HOOD

FIG. 2—WRIST FASTENING

FIG. 3—METHOD OF MAKING FRONT OF SUIT

FIG. 4 ANKLE FASTENING

Details of Inspection Suit

A cape of ample proportions should be attached to the hood and the caps should button in front and fit closely over the shoulders of the wearer. Fig. 2 shows the manner of fitting the suit around the wrist. Some are secured with a strap, others by a cord. The suit should be buttoned in front from top to bottom, and cut with a lap of several inches, as shown by Fig. 3, to prevent dirt from penetrating the suit.

The legs of the overalls are made long enough to reach to the floor and drag at least an inch when standing erect. Then the cloth is fastened closely around the ankles of the wearer. Two methods are used for fastenings at the ankles. One consists of tying a common shoe string around the ankle. The other method consists of a three-strap arrangement, two being fastened to two rings. One strap passes behind the ankle, and the other underneath the foot just forward of the heel. When the third is buckled closely it draws the fabric around the ankle and also prevents the leg of the overalls from pulling upward while crawling through restricted passages.

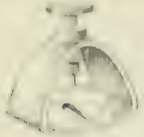


FIG. 5
STEAM GAGE JACK

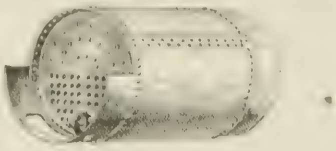


FIG. 6 – BURNED OUT DRY SHEET

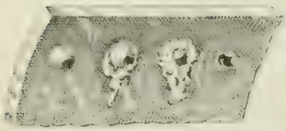


FIG. 7 – CORRODED RIVETS

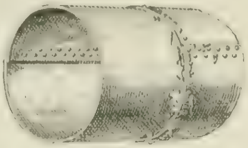


FIG. 8 – GIRTH SEAM DISTRESS AND CORROSION

POWER

DEFECTS TO GUARD AGAINST

Another arrangement is that of using two straps, Fig. 4. The front strap is omitted and replaced by a cord or a piece of leather-belt lacing which is passed through the rings, crossed over the instep, wound around the ankle, and then tied in front. This fastening is almost dirt-proof. High shoes should be worn, and the overalls drawn down outside and fastened.

Certain tools are required for inspection work, as, for instance, a peen hammer weighing about 1 lb. The peen should be crosswise of the hammer, and an ordinary riveting hammer answers very well. A small screwdriver is also necessary to use on the screws of steam gages; a small wrench or a pair of gas pliers can be used to disconnect steam gages.

Another tool is a little jack, Fig. 5, for removing the hand from a steam gage without bending the pinion, which is almost sure to be done if the attempt be made to remove the hand with a pair of pincers, knife or a claw hammer.

A gage-testing outfit is also necessary for testing steam gages. A light but strong steel chain about 6 ft. long, and a padlock should be used to lock the boiler stop valve, when there is more than one boiler on the line, so that the valve cannot be opened. A similar precaution may be taken with the feed-water pipe, but usually the removal of the check-valve cap offers ample protection against hot water entering the boiler.

WHAT TO LOOK FOR

The first thing to note is the condition of the boiler setting. The condition of the brickwork should be examined, also the fire surface of the shell, for signs of blistering, bulging or of burnt or corroded rivets. Specially should the front of the furnace be looked at, for, if the brickwork burns out or falls down, the dry sheet will burn, as shown in Fig. 6, permitting flames to pass directly from the furnace to the front smoke arch. This cannot happen with a full flush front boiler.

Next the seams should be inspected for signs of distress. Overheating seams frequently causes leaky rivets, and, although the rivets may have tightened up again, corrosive deposits may be found frequently around them. In locomotive and internally fired shells, very close search should be made for bulged plates, distorted sheets, signs of burning and bagging of plates between the stay bolts or braces.

The cause of such bulging should also be closely looked for. This will probably be found during the internal inspection and is usually due to dirt or scale in the boiler adhering to the plate and preventing water from reaching the shell. When that happens, undue heating takes place and the boiler shell may heat sufficiently to permit the internal pressure to bulge out the plate. If a bag is detected it should be examined closely and noted if, when struck with a hammer, it gives a sound indicating cracks or thin places. Small bulges are usually left alone; large ones must be removed because the pocket formed in the sheet collects sediment, which causes further overheating and bulging. Cutting out a bulge may not prove very satisfactory, as a pocket is still left which may cause trouble indefinitely. Forging a bulge back is easily done if the sheet is heated to a bright red.

CORROSION

All longitudinal seams of the boiler should be looked after to ascertain what corrosion, if any, exists. Along each of the outside straps there may be signs of rusting of the metal or a deposit of white-looking matter. Sometimes the deposit will be yellow or dark colored, depending upon the corrosive substance which has been acting upon the shell.

The peen of the hammer should be used to cut away the deposit and to determine how much, if any, the sheet has been reduced by the corrosive action. A steel scale is handy for this purpose. It can be placed edgewise against the boiler shell, one end of the scale extending over the corroded spot, then the distance from the scale to the boiler plate will equal the amount which has been removed by corrosion.

Corrosion of the boiler shell should be watched for closely. This is to be found either where the plate laps over on itself or where one comes against the inner or outer strap. By placing a corner of the steel scale against the joint, and parallel with the boiler it is easy to judge how much or how little wasting of plate has taken place. This is a very important part of the work, as a reduction of $\frac{1}{16}$ in. in the thickness of the boiler plate may cut down the allowable pressure enough to require taking the boiler out of commission.

The examination shows the physical condition of the boiler, and, from the data acquired, the safe working pressure for the boiler is calculated. The pressure carried in the boiler should be cut down to the amount thus determined, as a boiler is no stronger than the weakest spot.

CORRODED RIVETS

In Fig. 7 are shown corroded rivets, also one in good condition. Sometimes one is found as indicated by the second, almost completely covered with a white powdery-looking deposit which may go partly or completely around the rivet. Frequently greater action takes place, and the appearance shown by the last rivet is often found, and the top of the rivet can barely be seen in the center of a mass of corrosion.

When such rivets are found they should be removed, the holes reamed slightly and new rivets driven. Repairs should be made to all defective rivets. Sometimes the metal will be eaten away on two sides of the holes, as shown. It is possible to drive a new rivet in such a hole and very often the rivet fills the hole so tightly that no leak will take place, but it is much better and safer to ream the hole slightly, until it becomes round again, then drive a new and larger rivet.

Each girth seam should be looked at closely, not only for corrosion but for signs of distress.

Inspecting Girth Seams

Fig. 8 shows some things which one may expect to find about the girth seams. The deposits are caused by evaporation of the water as it issues from leaks in the boiler, leaving deposits of salts which fill the angle between the sheets or around the rivet heads. When leaks exist along a seam or beside a rivet, corrosion must eventually take place. Water cannot be forced through a crack in a hot metal plate without uniting with the metal of the plate to a greater or less extent. Some of the rivets may also show deposits. Such conditions indicate distress at the girth seam, and the cause should be closely investigated.

Usually the girth seams of boilers give little trouble as all they do is to hold the boiler together and withstand the pressure on the heads not carried by the tubes. Therefore, the inspector should look for other reasons for the distress shown at girth seams, such as low water at some previous time, for overheating will start girth-seam and rivet leaks very quickly. The method in which the boiler is suspended figures in the trouble. Sometimes boilers are so placed that expansion of the shell is restricted and excessive strains are caused in the girth seams.

⁂

Powdered Coal in Boiler Furnaces

Powdered coal, with suitable apparatus, can be made to produce complete combustion in boiler furnaces. This is no new discovery. About twenty years ago the practice began to develop and it is about fourteen years since C. Wegener introduced a powdered-coal-burning system in Europe wherein the use of blowers for forcing the coal to the furnace was eliminated, and the natural draft made to do this function. Then followed an interesting development of apparatus for using this form of fuel, and this activity still flourishes despite the little success in the practical application of the art. At present much experimenting is being carried on.

This manner of burning coal has many features to recommend it. Not only will coal burn better and more completely when pulverized, but coal high in volatile gases, when ground, will give up to the boiler much of the heat in these gases that goes to waste under ordinary firing and draft conditions. The draft must be very much lower when powdered coal is burned, for the volatile combustible burns more rapidly than the fixed carbon in powdered form, which will be carried unconsumed to the back of the setting even under the low draft. The coal must not enter the furnace at too high velocity and, to prevent rapid deterioration of the firebrick, must not impinge on any part of the setting. The ideal condition is one where the fuel burns completely in suspension.

The economical utilization of the cheaper grades of bituminous and slack coals is another important reason why a successful powdered-coal-burning apparatus would be welcome. True, these cheap fuels are being more extensively used, especially with the more general use of the stoker, but the high percentage of ash and moisture are productive of trouble. When in powdered form and suitably handled, the high ash and moisture content are not seriously objectionable except that pulverizing troubles arise from too high moisture content. The temperature in parts of the furnace when using powdered coal is often much higher than when burning ordinary fuel with stokers or by hand firing. As the fusing temperature of the firebrick is sometimes lowered by the combined action of the chemical constituents of both ash and firebrick, the composition and the fusing temperature of the ash are important.

With coal high in ash that slags, it becomes important to run off while hot the slag that accumulates in the bottom of the setting, especially if the boiler must be kept in continuous service for long periods. Lime, unslacked or as contained in clam and oyster shells, used as a flux will usually soften the slag so that it will flow or become plastic enough to permit of being pulled out with a hoe.

The evaporation per pound of powdered coal rightly burned is high, the labor cost is comparatively low and there is almost a total absence of smoke when burning the highly volatile coals in powdered form. While the years of endeavor have not resulted in the general adoption of this method of burning coal in boiler furnaces, the persistency with which experiments are carried on may result in the perfection of the art, so that it will prove superior to the stoker for burning many of the lower grades of fuel that now lie in mountainous piles in the coal regions.

⁂

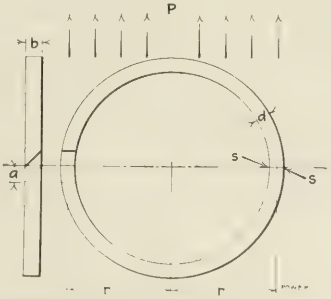
Proportioning Piston Rings

To calculate the pressure of piston rings against the cylinder walls, let

P = Total pressure of ring, in pounds;

p = Unit pressure of ring, pounds per square inch;

S = Unit stress at most remote fiber, pounds per square inch, at point s;



Piston Ring, Showing Where Measurements Should Be Taken

c = Distance from neutral axis of section to most remote fiber, inches;

I = Moment of inertia of section about neutral axis parallel to the face;

M = Maximum bending moment;

r = Mean radius of ring, inches;
a = Amount to be cut out of ring;
D = Diameter of cylinder bore;
b = Face of ring, inches;
d = Thickness of ring, inches;
F = Allowance for turning.

The fundamental flexure formula for beams is $S = \frac{Mc}{I}$.

Consider one half of the ring as a cantilever beam of length $2r$, and uniformly loaded with a load, P.

$$M \text{ for cantilever beams} = \left(\frac{P}{2}\right) \times (2r) = Pr.$$

$$c \text{ for rectangular sections} = \frac{d}{2}.$$

$$I \text{ for rectangrlar sections} = \frac{(bd^3)}{12}.$$

Substituting in $S = \frac{Mc}{I}$.

$$S = \frac{\frac{Prd}{2}}{\frac{(bd^3)}{12}} = \frac{\frac{Pr}{2}}{\frac{(bd^2)}{12}}$$

* * *

Reducing P to pounds per square inch projected area = $2rbp$. Substituting

$$S = \frac{\frac{(2\,rbp)\,r}{2}}{\frac{(bd^2)}{12}} = \frac{pr^2}{\frac{d^2}{12}}$$

Solving for p.

$$p = \frac{Sd^2}{12\,r^2}$$

The amount a to be cut out of the ring may be assumed some even figure from about ⅜ in. for the smaller sizes of cylinders to ¾ or ⅞ in. for the larger sizes of 16- or 20-in. bore.

After assuming the value for a, the outside diameter of the cylindrical blank from which the rings are cut would be

$$D' = D + \frac{a}{3.1416} + F$$

The rings are then cut off with the required width b, and, after the slot a is cut, they are sprung together and turned to the same diameter as the cylinder bore.

* * *

Compounding Simple Reciprocating Engines

By L. H. Morrison

SYNOPSIS—How two engines of different capacity and running at different speeds were piped to run as a compound condensing unit. The directly connected generators were run in parallel without trouble, notwithstanding predictions made to the contrary.

* * *

About a year ago the writer assisted in designing a municipal electric-light plant, some features of which are worthy of mention.

A city of approximately 6000 inhabitants purchased the franchise and physical property of the Electric Light & Water Co., and found it necessary to build an entirely new plant. It was also determined to install a central steam-heating system to operate in conjunction with the lighting plant, this system to cover all the business district and a part of the residential section.

It was desirable that the generating units be the most economical obtainable with the amount of money available. Furthermore, to determine the capacity of the new units, recourse was had to the old company's records which revealed that during the winter the maximum demand was about 350 kw., and the maximum required during the summer was approximately 225 kw. The average consumptions during these two periods had about the same ratio.

The sizes of the units necessary was the first thing to be considered, and a 100- and a 225-kw. unit were decided upon. The two units combined were ample to carry the maximum winter load with the prospective increase for several years. On the other hand, the 100-kw. set could carry the light day load in summer and the 225-kw. unit was ample to handle the heavy summer load. It was imperative that two units be installed as a safeguard against a total shutdown, with the additional reason that it was a good business proposition to have that unit in operation at any time that it would be carrfying approximately full load.

As a first step toward choosing the type of prime mover to be installed, the turbine was investigated and discarded, because of the high steam consumption of the smaller sizes, especially when operated noncondensing and with a back pressure. Although the steam consumption was of small moment during the two months of extremely cold weather, during the autumn and spring the steam necessary for the heating system would be small; consequently the economy with noncondensing operation was of importance and more than offset the low installation cost of the turbines.

Similarly the high-speed, single-valve engine was discussed and discarded in view of the ever increasing steam consumption of this type, while even the consumption, when the engine was new, was entirely too high for this plant. This narrowed the field to two types, the Corliss and the four-valve engine.

Investigation seemed to prove that as regards cost of operation and upkeep there was little to choose between these two types. In view of the demand that the cost of current be as low as possible, the compound engine seemed almost essential. However, the money available was insufficient to purchase two compounds and, as has already been stated, it was desirable to have the two units. Finally it was decided to purchase two simple engines and arrange to operate them part of the time as a compound engine.

This idea was taken up with various engine and generator builders, but none would vouch for the success of the arrangement. The engine people stated that the engines would operate satisfactorily if the generators did not develop heavy cross-currents. The generator people were quite willing to guarantee the operation of the alternators if the engines would regulate.

All stated that it was a proposition entirely new to them. However, in spite of the lack of builders' guarantees it was decided that the plan should be carried out. It was impossible to buy two compound engines and any gain in steam consumption with the compounding plan over simple engines would be clear gain. Furthermore, the cost of a receiver and the necessary piping was not excessive.

Bids were invited on the installation of two 72-in. by 20-ft. horizontal tubular boilers for 175 lb. working pressure, a 100- and a 225-kw. engine and generator unit together with condenser, piping and the usual accessories. The generators were to be 2300-volt, three-phase, 60-cycle, directly connected to the engines and to have belted exciters. The bidders were required to give steam consumptions with engines operating both noncondensing and condensing. The city assumed responsibility for the compounding arrangement and so this plan was not discussed with the bidders.

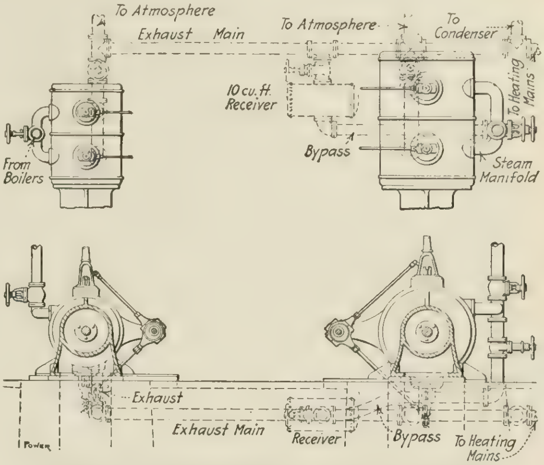
Finally, because of extremely low steam consumption and evident high-grade of workmanship entering into the construction, two improved, four-valve German-design engines were purchased with the other machinery called for. The engines were a 12x18-in., operating at 225 r.p.m., directly connected to a 100-kw. alternator, and a 19x27-in. engine directly connected to a 225-kw. alternator running at 150 r.p.m. It was desired to have both engines run at the same speed, but the cost of the smaller unit at 150 r.p.m. was so high as to over-run the available money.

Both engines were connected to a main exhaust line, as shown in the illustration. There was also an independent atmospheric exhaust line from each engine. The main exhaust line, immediately beyond the large unit, was connected to a jet condenser. The bypass with its connecting receiver is shown. This bypass was connected to the live-steam manifold of the large engine from below, this engine being equipped with two throttle valves, one controlling the line from the boilers, the other controlling the steam from the bypass.

The method of operating the plant is as follows: During the season of steam heating, the engines are operated noncondensing and exhaust directly into the heating mains At times one engine handles the load, but during the greater part of the time both are operated with the generators run in parallel. During the warm months when the load is less than 75 kw., the small unit is operated condensing. When the load increases, the two engines are started on live steam, and the generators are then thrown in parallel. This being accomplished, the small-engine exhaust is cut off from the large-engine exhaust beyond the bypass, the exhaust passing out through an independent atmospheric line through a back-pressure valve, the weight of which can be altered at will. The bypass is then opened and the live-steam throttle gradually closed. When the pressure in the bypass reaches about 30 lb. or more the live-steam throttle is entirely shut off, and the bypass throttle opened. The weight on the back-pressure valve of the small engine is then shifted so that it will not open with less than 80 lb. pressure.

As the back-pressure instantly shows up on the small engine or high-pressure cylinder, the cutoff occurs later, according to the load on the generator. The same occurs with the large engine or low-pressure cylinder. The capacity of the receiver, 10 cu.ft., prevents fluctuations of the receiver pressure that were expected to occur, due to the different engine speeds.

It had been freely predicted that the regulation would be faulty, especially that of the large engine. On the contrary, the two units operated as smoothly as when running as simple engines. It developed that the small engine's governor shifts often while the large engine governor's movement is very slight. This is probably explained by the fact that as the load decreases the cutoff of the small engine becomes shorter, thereby lowering the terminal and receiver pressure; this reduction of pressure would decrease the power of the large engine with the same cutoff as before. Consequently the governor is not shifted as frequently. The cross-currents between the generators do not develop as many had feared. In fact, the operation is as good as found with many regular compound engines.



Simple Engines Piped to Run Compound

While the steam consumption of the combined units is about 2 lb. higher than that of a compound engine, it is very evident that the greater part of the preventable loss is due to the lowered efficiencies of the two generators, since they are not operated at full load. Also, there would probably be a slight gain if the engine cylinders had a better ratio and the revolutions were the same.

It is now proposed to run the exhaust-steam line from the condenser pump into the receiver, thereby giving an additional amount of steam to the low-pressure cylinder; the exhaust from the boiler-feed pump being ample for heating the feed water.

While it is a debatable question if such an arrangement of compounding is often advisable, still in this case it works satisfactorily and indicates the flexibility that it is possible to secure in a medium-size light plant.

⁂

How to Take Rope From a Coil Without Kinking—The Plymouth Cordage Co. gives the following directions: Place the coil on its head with the inner end of the rope at the bottom, then draw out the end anticlockwise and throw the rope as it comes out so that it will fall in the same direction as that taken during the unwinding. Where storage space is limited, it may be necessary to draw from the outer end of the rope.—"Mill Supplies."

Air of Infiltration

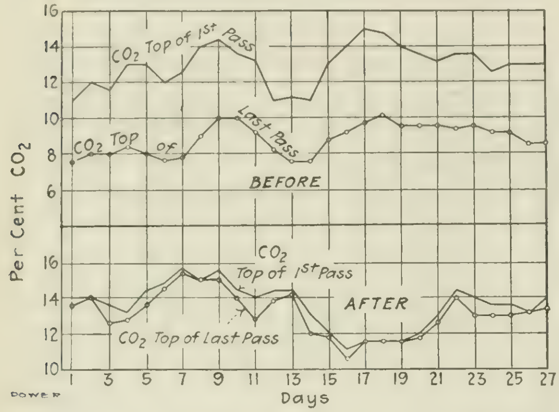
By Morgan B. Smith

SYNOPSIS—Description of and data from tests showing effects of air leakage into boiler settings considered reasonably tight, and the method employed to secure practically absolute air-tightness.

⁂

In a plant of some 20 odd boilers aggregating 7000 hp. (rated), two boilers continually showed a lower efficiency of combustion than the rest, although all were similarly constructed and operating on the same fuel. The flue gases were analyzed daily for CO_2 with a recorder and frequent tests were made with the Orsat for CO_2, CO and O. Finally, two Orsats were employed, one for the gases at the top of the first pass, the other just before the back damper at the top of the last pass.

The tests at once showed that the gases as they left the boiler had become diluted as compared with the gases at the point of gas travel where combustion was practically just completed. The dilution was caused by air, as shown by the analyses of the gases, and inasmuch as none had been admitted through the furnace which had not been accounted for in the analyses taken at the top of the first pass, it is evident that air which had not passed through or over the fire bed must have found its way into the boiler through the setting itself.



CO_2 Record for 27 Days Before and After Setting Was Made Tight

We at once began a thorough investigation of this setting and prepared to stop the entrance of any air except that which rightfully came in through or over the fuel bed. We found bad joints in the brickwork, and porosity tests of bricks similar to those used in the setting showed that considerable air could readily pass through them when under the influence of difference in pressure; door frames were loose in the brickwork, and we located numerous points of entrance for air which before had passed unnoticed.

The first step was to thoroughly remove the old worn-out lime mortar in the joints of the brickwork to a depth of fully 1 in., after which the bricks were cleaned by brushing with wire brushes. The joints were then pointed up carefully with a cement composed of fireclay mixed with portland cement and water. It was found that an addition of ammonia water tended to retard the setting somewhat and render the mixture more resistant to temperature changes, the amount added being sufficient to give the mixture a fairly strong odor of ammonia. The joints were made flush with the surfaces of the bricks and allowed to set for two days.

After the cement had solidified, the whole setting, brickwork and iron were painted with a heavy, slow-drying asphaltum-base paint, of such character as to give a flexible coating not easily cracked or peeled from the bricks. It was necessary to first point up the joints with the cement-fireclay mortar because some of the cracks were larger than the paint could safely close effectively. All the door frames were set tightly in the brickwork and then given a heavy coat of the same paint, especially where the iron joined the brickwork. Three coats in all were applied, each being allowed to dry somewhat before the application of the next. The total time consumed in improving this setting was 10 days. The results produced caused us to carry out a similar program on all the other settings.

Herewith are some figures, calculated on the basis of pure carbon for fuel, showing the saving which may be obtained when boiler settings are maintained in air-tight condition. It should be noted that the conditions in this plant were not abnormal; in fact, the writer, since this particular investigation, has observed many cases far worse.

The chart in the figure shows the result of tests covering 27 days in terms of CO_2 in the gases of combustion. The samples were taken at the top of the first and at the top of the last pass in the gas travel of a 500-hp. Stirling boiler, fitted with a Roney stoker. The draft was natural, averaging 0.175 in. of water over the fire. The CO_2 tests were made simultaneously by two operators, who changed positions and Orsats frequently in order to eliminate the personal equation as far as possible.

It is interesting to note the regularity with which, for the most part, fluctuations in CO_2 in the first pass are followed by fluctuations in the last.

The average CO_2 at the top of the first pass was 13 per cent. for 27 days before the setting was overhauled and 8.8 per cent. at the top of the last, a difference of 4.2 per cent. This loss in CO_2 is undoubtedly a measure of the dilution of the gases of combustion due to air of infiltration and corresponds to an increase in the excess air equal to 75 per cent. of that theoretically required. The excess at the top of the first pass was close to 60 per cent. and 135 per cent. at the top of the last. This increase in excess air (75 per cent.) corresponds to a loss in fuel of approximately 5.5 per cent. (based on pure carbon).

After rendering the setting practically air-tight, the difference in CO_2 content of the gases was reduced to 0.5 per cent., the CO_2 at the top of the first pass being 13.6 per cent., as against 13.1 per cent. at the top of the last. This difference represents closely an increase in excess air of only 5 per cent. (compared with an increase of 75 per cent. formerly), which in turn approximates a fuel loss of only 0.25 per cent., or practically zero when the accuracy of analysis of gases and unavoidable error are considered.

There can be no doubt of the value of careful treatment of boiler settings; the figures are strong evidence that all heat-absorbing parts of boilers should be housed in air-tight settings, there being considerable value in the suggestion that all boiler brickwork be covered with sheet iron, applied in sections so that working parts may be accessible for cleaning, etc. Excellent results may be obtained, however, with suitable paint. Such a paint is gummy in nature, heals when scratched and gives a heavy, impervious coating which does not become "tacky" even at the front part of the setting near the combustion chamber. There are several such paints on the market; the paint we used is sold in all the principal cities of this country.

CO_2 ANALYSIS IN PER CENT

Boiler Setting	Before First Pass	Before Last Pass	After First Pass	After Last Pass
A	10.7	7.2	10.9	10.3
B	15.0	10.1	14.8	14.7
C	11.85	7.3	12.1	11.3
D	13.6	7.6	13.22	12.4

EXCESS AIR CORRESPONDING TO ABOVE CO_2 CONTENTS

A	93.0	187.5	90.0	100
B	40.0	105.0	41.0	40.85
C	73.0	185.0	71.0	82.5
D	52.5	172.5	56.0	67.5

FUEL LOSS CORRESPONDING TO DIFFERENCE IN CO_2 BETWEEN FIRST AND LAST PASS, PER CENT.

A	8.25	0.75
B	5.75	0.00
C	10.00	1.00
D	10.75	0.90

Above are figures showing the results of such treatment on several other settings figured as above. The savings shown in fuel consumption are, of course, calculated theoretically. However, actual tests in which the fuel was weighed and calculated in terms of B.t.u. per kilowatt-hour of current generated, before and after treating the settings, showed close checks on the theoretical figures.

In all this work the same fuel, Hocking Valley slack, was used and showed a heat value of about 12,800 B.t.u. per pound, and a content 8.5 per cent. ash and 1.5 per cent. sulphur.

*

Calculating Weight of Stacks

For use in estimating the weights of circular steel stacks and smoke breechings, the accompanying table is given by Charles R. Courtenay in the *American Machinist* for Sept. 11, 1913. The table gives the actual weight of a round steel tube 1 ft. long, including longitudinal lap. For stacks No. 8 to No. 3 gage, it is only necessary to add 1½ or 8⅓ per cent. of the weight given for every girth seam in the stack.

Example—How much will the plate of a 22-in. diameter by 20-ft. stack weigh if the material is No. 16 gage stock and the length of each section, including lap, is 50 in. From the table, the weight per foot is 16.4 lb.

$$20 \times 16.4 = 328\ lb.$$

There are four girth seams because

$$\frac{20\ ft. \times 12}{50} = 5,\ nearly$$

and 5 — 1 = 4.

Then

$$8\tfrac{1}{3}\ per\ cent.\ of\ 16.4 \times 4 = 5.46\ lb.$$

is the extra weight for seams (girth) and

WEIGHT-CALCULATION TABLE. WEIGHT PER FOOT OF ROUND STACKS

	Use ½" Rivets—Lap 1¼"								Use 5/16" Rivets—Lap 1"										
	0	1	2	3	4	5	6	8	10	12	14	16	18	20	22	24	26	28	30
Diameter	5/16"	9/32"	17/64"	1/4"	15/64"	7/32"	13/64"	11/64"	9/64"	7/64"	5/64"	1/16"	1/20"	3/80"	1/32"	1/40"	3/60"	1/64"	1/80"
8										11	7.6	6.1	4.9	3.68	3.04	2.65	1.82	1.52	1.23
9										12.4	8.55	6.8	5.5	4.02	3.51	2.73	2.05	1.71	1.34
10									17	13.8	9.4	7.8	6.06	4.53	3.78	3	2.27	1.87	1.53
11									18.7	15.	10.4	8.31	6.64	4.97	4.14	3.22	2.49	2.07	1.66
12									20.3	16.4	11.3	9.04	7.36	5.41	4.51	3.61	2.71	2.26	1.84
13									22	17.7	12.2	9.8	7.8	5.85	4.82	3.91	2.93	2.45	2.01
14									24.3	19	13.1	10.51	8.41	6.46	5.24	4.2	3.15	2.62	2.10
15									25.3	20.4	14.1	11.2	9.	6.73	5.61	4.49	3.37	2.81	2.22
16								33.7	27	21.7	15	12	9.58	7.17	5.98	4.79	3.55	3	2.49
17								35.6	28.6	23	15.9	12.7	10.2	7.51	6.34	5.08	3.74	3.18	2.5
18								37	30.3	24.4	16.8	13.4	10.8	7.96	6.71	5.37	4.03	3.36	2.64
19								39	32	25.7	17.7	14.2	11.3	8.49	7.17	5.66	4.25	3.54	2.86
20							49	41	33.6	27	18.7	15	11.9	9.2	7.44	5.95	4.47	3.73	3.0
21							51.5	43	35.2	28.4	19.6	15.6	12.5	9.47	7.81	6.25	4.69	3.91	3.15
22							53.8	45.1	36.9	29.7	20.5	16.4	13.1	9.81	8.17	6.54	4.91	4.1	3.36
23							55.9	47.1	38.5	31	21.4	17.1	13.7	10.2	8.54	6.73	5.13	4.28	3.45
24							58.7	49.1	40.2	32.4	22.3	17.8	14.3	10.6	8.9	7.12	5.41	4.46	3.56
25						65.8	61.1	51.1	41.8	33.7	23.2	18.6	15	11.1	9.27	7.42	5.57	4.65	3.68
26						68.3	63.5	53.1	43.5	35	24.2	19.3	15.5	11.5	9.64	7.71	5.79	4.82	3.86
27						71	66	55.2	45.1	36.3	25.1	20.1	16.04	12.1	10.	8	6.01	5.02	4.01
28						73.5	68.2	57.2	46.8	37.7	26	20.8	16.6	12.3	10.3	8.3	6.23	5.2	4.15
29						76	70.6	59.2	48.4	39	27	21.5	17.2	12.8	10.7	8.59	6.44	5.38	4.30
30				89.8	84.3	78.6	73	61.3	50	40.4	27.8	22.3	17.8	13.3	11.1	8.92	6.67	5.57	4.45
31				92.8	87	81.2	75.4	63.2	51.7	41.7	28.7	23	18.4	13.8	11.4	9.18	6.89	5.75	4.59
32				95.7	89.8	83.8	77.8	65.3	53.4	43	29.7	24.1	19	14.2	11.8	9.47	7.16	5.93	4.74
33				98.6	92.6	86.3	80.2	67.2	55	44.4	30.6	24.5	19.6	14.6	12.2	9.76	7.33	6.05	4.89
34				101.6	95.3	89	82.6	69.3	56.7	45.7	31.5	25.2	20.2	15.1	12.5	10	7.55	6.3	5.09
35			111	104.5	98.1	91.4	85	71.3	58.3	47	32.4	26	20.7	15.5	13	10.3	7.77	6.42	5.16
36			114.2	107.4	100.8	94	87.3	73.3	60	48.4	33.3	26.7	21.3	16	13.3	10.6	7.92	6.6	5.33
37			117.3	110.4	103.5	96.6	89.7	75.3	61.6	49.7	34.3	27.4	21.9	16.3	13.6	10.9	8.26	6.85	5.48
38			120.4	113.3	106.2	99.1	92.3	77.4	63.3	51	35.2	28.1	22.5	16.8	14.01	11.2	8.49	7.02	5.63
39			123.5	116.3	109	101.7	94.5	78.7	65	52.3	36.1	28.9	23	17.2	14.4	11.5	8.68	7.15	5.77
40	149.2	134.1	126.6	119.2	111.8	104.3	97	81.4	66.6	53.7	37	29.6	23.7	17.7	14.8	11.8	8.89	7.39	5.92
42	156.4	140.7	132.9	125.1	117.2	109.4	101.6	85.4	70	56.4	38.8	31.1	24.9	18.5	15.5	12.3	9.34	7.76	6.14
44	163.7	147.3	139.1	131	122.8	114.6	106.4	89.5	73.2	59	40.7	32.5	26.03	19.4	16.2	12.9	9.75	8.07	6.5
46	171	153.9	145.4	136.8	128.3	119.6	111.2	93.5	76.5	61.7	43.5	34	27.2	20.3	16.9	13.5	10.1	8.45	6.8
48	178.4	160.5	151.6	142.7	133.8	125	116	97.6	79.8	64.3	44.3	36.1	28.4	21.2	17.6	14.2	10.6	8.82	7.09
50	185.7	167.2	157.9	148.6	139.3	130	120.7	101.6	83	67	46.2	37	29.6	22.1	18.4	14.6	11	9.18	7.39
52	193.1	173.7	164.1	154.4	144.8	135.6	125.5	105.6	86.4	69.7	48	38.4	30.7	23.1	19.1	15.3	11.5	9.6	7.68
54	200.4	180.4	170.3	160.3	150.3	140.3	130.3	109.7	89.8	72.4	50	40	31.9	23.8	19.9	15.9	11.9	10	7.97
56	207.8	187	176.6	166.2	155.8	145.5	135.1	113.7	93.5	75	51.2	41.4	33.1	24.7	20.6	16.5	12.3	10.3	8.27
58	215.1	193.6	183	172.1	161.4	150.6	139.8	117.6	96.5	77.7	53.5	42.6	34.3	25.6	21.3	17.1	12.8	10.7	8.56
60	222.4	200.2	189.1	178	167	155.7	144.6	121.8	99.7	80.3	55.4	44.3	35.4	26.5	22	17.6	13.2	11	8.85
62	229.8	206.8	195.3	183.8	172.4	160.8	149.4	125.8	103	83	57.2	45.8	36.9	27.4	22.8	18.2	13.7	11.4	9.15
64	237.1	213.4	201.6	189.7	178	166	154.2	130	106.3	85.7	59	47.2	37.8	28.2	23.5	18.8	14.1	11.8	9.4
66	244.5	220	207.8	195.6	183.4	171.2	159	134	109.6	88.3	60.3	48.7	39.3	29.2	24.2	19.4	14.6	12.1	9.7
68	251.8	226.6	214	201.4	189	176.4	163.7	138	112.9	91	62.7	50.2	40.3	30	25	20	15	12.5	10
70	259.1	232.2	220.3	207.3	194.3	181.4	168.5	142	116.2	93.6	64.5	51.6	41.4	31.1	25.7	20.6	15.4	13	10.2
72	266.5	238.8	226.5	213.2	200.5	186.8	173.3	146	119.5	96.3	60.4	53.1	42.7	31.8	26.5	21.2	16	13.4	10.6

Add 15⅜ % of above for each girth seam.

Add 8⅓ % of above for each girth seam.

These weights include allowances for over weights as adopted by The Ass'n American Steel Mf'rs.
Does not include bands, guy wire and rivets

328 + 5.16 = 333.16 *lb.*

is the total weight of plate in the stack.

If the gage stock had been No. 0 to No. 6, we would have had to use 15⅝ per cent. instead of 8⅓ per cent., as the lap for these gages is 1⅞ in. instead of 1 in. for the lighter gage stock. To obtain the total weight of material in a stack, it is only necessary to add to the plate weight the weight of rivets and bands.

⁂

Economical Power-Plant Combination*

By W. J. Smith

SYNOPSIS—Steam boilers are used to generate steam for manufacturing purposes, but power is obtained from a gas-producer, gas-engine plant. An interesting arrangement is that of using the ammonia condenser water in the gas-engine jackets, for cooling the engine-exhaust pipe and in the producer humidifier and lastly pumping the remainder to the boilers.

⁂

Under certain conditions combinations of prime movers may be made which will produce economy and reliability of operation. An interesting example of this is found at the plant of the Olympia Brewing Co., Olympia, Wash., where a combination of producer-gas engine and oil-fired steam boilers has brought about remarkably good economy and efficiency. Apparently, due to certain requirements of the industry, no other form of power, as at present developed, can successfully displace that in use.

Boilers

Both boilers are water-tube, each of 250 hp. capacity. The steam requirements are such that only one is in service at a time, and they are used alternately, a month at a time, which serves to keep both in better condition than if one were idle all the time. The steam is used in the various departments for heating and brewing requirements, none being used for motive power. Both boilers are operated at high pressure, reducing valves being placed in the steam lines as required. The returns are handled by tilting traps on the various lines, which in turn deliver to a direct-return tilting trap, mounted above the boilers.

The gas producer was developed and practically built on the premises, and is designed primarily for the low-grade lignite coals of this region. It is of 250 hp. capacity, and is charged from an overhead hopper or coal pocket, the normal charge being about 850 lb., which is introduced through four feed openings or hoppers, every three hours. The gas product is used in a 250-hp. gas engine, belted to a 125-ton ice machine, and a 150-kw., 220-volt, direct-current generator, used for lighting and motors on the numerous pumps and auxiliaries about the plant.

Water Supply

An ice machine serves the various cooling processes in the brewery, and also furnishes 25 tons of ice per day, which is used for icing cars, city ice service, etc. Water used for cooling the ammonia condensers is brought to a nearly uniform temperature of 68 deg. F.; 30 per cent. of this is used in the jackets of the gas-engine cylinders, which brings it up to a temperature of 130 to 140 deg. F. From the cylinder jackets the water is led to a jacket about the exhaust pipe of the engine and an exhaust-heat economizer which raises it to nearly boiling point and at the same time cools the burned gases of the exhaust and makes the discharge of the latter much less violent and noisy. From this point the water is piped at its now high temperature to the humidifier part of the producer apparatus, where the entering air is given the proper moisture content, making a gas in which the various necessary elements are combined. This last stage reduces the water temperature to between 160 and 170 deg. F. Part of it is used for boiler-feed water and before entering the boiler is again brought to a high temperature by circulating through a coil in the last pass of the waste gases before the latter enter the stack. The remaining water is then piped over the plant and is used in all washing processes, such as for beer packages, etc., its temperature being from 20 to 30 deg. above the pasteurizing point, which is 140 deg. F.

All of the foregoing has been accomplished through what are common avenues of extensive loss; first, the necessary cooling of the ammonia condensers; second, the essential cooling of the gas-engine cylinders and exhaust gases, and, third, the waste heat in the flue gases of the boiler furnace.

An engineer and a fireman operate the power plant, the latter taking care of both boilers and the producers. The boilers being oil-fired, the feed water handled by electrically driven pumps and the return system of traps feeding the boiler, the plant is more or less automatic in operation. The producers require attention every three hours and it takes 20 min. to clean and charge at each period.

Fuel

Locally mined coal is used, costing $1.70 per ton delivered, only the lower grades being used, in fact, a considerable quantity of it was formerly waste. Although the freight haul is short, the transportation item is nearly 50 per cent. of the cost of the fuel. About 7200 lb. is used daily. At times an overload of from 10 to 20 per cent. is carried by the gas engine, nevertheless, extended tests have shown the fuel consumption to be in the neighborhood of 1.7 lb. per hp.-hr.

The average analysis of the coal used is as follows:

	Per Cent.
Moisture	16.2
Volatile matter	28.9
Fixed carbon and sulphur	32.1
Ash	22.8
Total	100.0
Heat value as fired, B.t.u.	7560
Heat value dry coal, B.t.u.	9021

For steam generation about 12 bbl. of California crude oil is used daily, costing $0.95 per bbl., delivered at the plant. With this oil is mixed a tar byproduct which is obtained from the gas scrubbers. This tar, amounting to 150 lb. daily, is rich in hydrocarbons and high in heat value. For a considerable period its use was a problem and it went to waste. Later, however, by a system of reheating to render it more fluid and to better separate the water content, it was found to mix perfectly and thus was developed one factor in making the plant highly economical.

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*The operating conditions of the gas-engine part of this plant were described in detail in "Power," Apr. 29, 1913, p. 604.

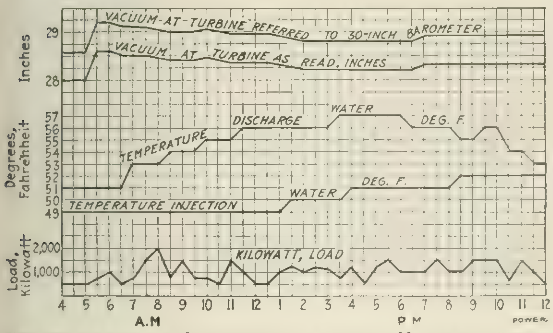
For the gas engine about one gallon of lubricating oil is required daily, costing $0.35 a gallon. This seemingly small quantity is found ample and after three and a half years' constant service the cylinders are in apparently as good condition as when installed.

The fuel cost for operating a plant of this capacity is extremely low. Comparison of operating costs between the plant as formerly driven entirely by steam power with simple noncondensing Corliss engines, and as at present equipped, shows a saving averaging more than $20 per day—the daily consumption of fuel oil alone then being about 45 bbl. It is likely that the actual saving is even greater than this, as additional equipment, requiring much more power and steam consumption, has been added since the installation of the present power plant.

Operating Condenser without Hotwell Pump

By H. C. Carroll

During the floods in March of this year, it became necessary to operate a large condensing turbo-generating unit without its motor-driven hotwell pump, the motor of which had become water-soaked. This, necessarily, meant that the unit would have to be operated noncondensing, but with only a bunker full of coal and over a 1000 ft. of the railroad siding washed out, it was evident that the coal in the bunker would not last until coal could again be brought in the regular way.



Performance of Condenser without Hotwell Pump

The generating unit consisted of a 6000-kw., double-flow turbine direct-connected to a 10,000-kv.-a., 25-cycle generator. The auxiliary apparatus consisted of an 18,000 sq.ft. dry tube surface condenser, engine-driven circulating pump, steam-driven air pump and the motor-driven two-stage hotwell pump.

It was decided to try operating condensing, letting the air pump take care of both the noncondensible vapors and the condensed steam as well. How well this did so, is shown by the accompanying set of curves derived from the half-hourly readings taken from the daily log sheet. How much more condensed steam the air pump could handle, is not known, but it handled all the condensed steam from the largest load at that time, up to 2000 kw. The bunker full of coal lasted nearly ten days when coal was again available over the siding.

A Decimal Classification for Power-Plant Data

By Frank H. Jones

Assuming the integral number 10 as representing a typical power plant, drawings and other data relating to design and actual work of construction may be conveniently classified and marked for filing as follows:

10. POWER PLANTS

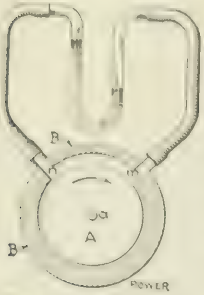
10.0	GENERAL
10.001	Studies and schemes.
10.01	Preliminary to Construction (Information necessary for a clear interpretation of the existing conditions on the site at the time of contract).
10.011	General Plan and Location, Topography.
10.012	Surface and Subsurface Investigations.
10.02	Canvass, Progress, Completion, Maintenance.
10.021	Bidders and Canvass or Bidders.
10.022	Progress Data.
10.023	Completion (guarantee of workmanship and material).
10.029	Maintenance, Instructions for, general.
10.03	Contractors Force, Material, Plant, Inspection.
10.31	Contractors Plant.
10.032	Force Accounts, Labor.
10.033	Material, Tests.
10.039	Engineering and Inspection.
10.04	Railroad and Highway Connections.
10.041	Foreign Trackwork.
10.042	Highway Connections.
10.1	SUBSTRUCTURE
10.11	Excavation, Filling, Surfacing, Grading.
10.12	Retaining Walls, Quay Walls.
10.13	Piles and Pile Records.
10.2	SUPERSTRUCTURE (including coaling and ash handling facilities and other minor structures).
10.21	Floors, Walls, Elevations, Sections, Roof.
10.211	Foundations.
10.22	Structural Steel.
10.3	PIPING
10.31	Underground Piping,
10.32	Plumbing, Commercial Water Supply.
10.33	Fire Protection System.
10.34	Plumbing, Sewage and Drainage.
10.35	Heating and Ventilating.
10.36	Other Pressure Systems.
10.39	Pipeway Construction, Ducts, Manholes, Dry Wells, Pits.
10.4	ELECTRIC POWER AND LIGHT (for the structure itself). If outside service is used the wiring data up to the main switchboard is classified herein (10.4). If an isolated plant is installed for this purpose the construction and wiring data shall be classified herein (10.4).
10.41	Distribution (includes all wiring layouts from, and including, the main switchboard to the finished outlet.
10.42	Appliances (Details from the point of outlet).
10.5	CHIMNEY
10.51	Foundation.
10.52	Stack.
10.6	POWER-GENERATING EQUIPMENT
10.61	Boilers.
10.611	Settings, Smoke Flue.
10.612	Fittings and Apparatus.
10.62	Steam Engines.
10.621	Reciprocating.
10.622	Turbine.
10.63	Hydraulic Engines and Machines.
10.631	Waterwheels.
10.632	Turbines.
10.633	Pumps.
10.639	Miscellaneous.
10.64	Electrical Generation and Distribution.
10.641	Generators and Motors.
10.642	Storage.
10.643	Transformation.
10.644	Transmission.

The absence of strictly technical classification under some of the headings, notably 10.6, is a commendable feature where the system is to be handled by index clerks with little or no technical knowledge. Though draftsmen and engineers would be able to use a more detailed classification than is shown, the majority of general office clerks would not be able to apply such a thorough outline with accuracy and intelligence.

The logical arrangement of data and the inclusive divisioning eliminate the need of an alphabetically arranged working key and as a standard classification can be readily adapted to large, small and general power-plant engineering data.

Dr. Gaede's Molecular Air Pump

The antithesis of the "viscosity" turbines of Tesla and others, which turbines have no blades but are carried around by the fluid friction of the steam, is the molecular air pump of Doctor Gaede. This consists simply of a cylinder *A* mounted upon a shaft *a* and running freely but fairly closely within the casing *B*. A pocket *nm* is formed in the casing and as the cylinder is revolved the air is carried with it, producing a difference in pressure at the different ends of the pocket, as shown by the manometer in the sketch. The inventor says that with a pump driven by a $\frac{1}{3}$-hp. motor a Roentgen tube of 1 liter volume can be exhausted to a vacuum of 5 mm. in 10 sec. The operation is from five to ten times as rapid as in the ordinary pump.



THE GAEDE MOLECULAR AIR PUMP

The following table gives the relations between the pressure differences and the revolutions per minute, but our information, which comes from *Die Naturwissenschaften,* does not include the diameter of the runner nor allow the peripheral speed to be calculated:

r.p.m	p_1	p_2
12,000	0.05	0.0000002
12,000	1.00	0.000005
12,000	10.00	0.00003
12,000	20.00	0.0003
6,000	0.05	0.00002
2,500	0.05	0.0003

OBITUARY

JAMES T. HADLEY

James T. Hadley, aged 42, secretary-treasurer of the Reid Gas Engine Co. and of the Reid Land Development Co., died at his home in Oil City, Penn., Dec. 28, after a long illness.

MURRAY FORBES

Murray Forbes, aged 50 years, died at his home in Greensburg, Penn., Dec. 28. He was a native of Philadelphia. In 1886 he settled in Greensburg and since then had been identified prominently in the water plant and power business. At the time of his death he was treasurer and general manager of the Westmoreland Water Co. He was a heavy stockholder in the Derry Water Co., Irwin Water Co. and the Dennison Water Co., Dennison, Ohio. Mr. Forbes was a son of William S. Forbes, professor of surgery at Jefferson Medical College, Philadelphia, and was a member of several scientific and engineering societies.

HERMAN MEINHOLTZ

Herman Meinholtz, vice-president and superintendent of the Heine Safety Boiler Co., died Dec. 24. His death was due to heart trouble, following an illness of two weeks, and occurred at his home in St. Louis. He was born in St. Louis, Feb. 7, 1868, and received his education in the St. Louis grammar schools and the manual training school and night classes of Washington University. Following a year of work with Prof. J. B. Johnson, at Washington University, Mr. Meinholtz was successively employed with Shickle, Harrison & Howard, the N. O. Nelson Manufacturing Co., and the Heine Safety Boiler Co., all in St. Louis. From 1895 to 1900 he was engaged in supervising boiler construction in various contracting shops. Since that time he has been in full charge of the Heine shops. The present shops, completed in 1909, were designed and their construction supervised by him. Mr. Meinholtz was a member of the American Society of Mechanical Engineers and an active participant in the work of the Boiler Rules Committee.

Los Angeles Power Plans

Plans to develop a municipal power project, involving an expenditure of $10,000,000 in Mono County, were outlined before the State Board of Water Power Control by attorneys and engineers representing the city of Los Angeles recently.

A tunnel 26 miles long to carry water from streams tributary to Mono Lake into the Owens River valley, where it will be merged with the Los Angeles aqueduct project, is one of the most pretentious features of the proposed undertaking.

Three power plants in Mono County are also projected. These plans were revealed in explanation of Los Angeles' opposition to the application of E. G. Ryan, a Southern Pacific detective, who had asked for permits to appropriate water from Rush Creek and Leevining Creek in the vicinity of Mono Lake. At the conference Assistant City Attorney S. B. Robinson declared that it was his opinion that Ryan was representing the Chappell interests which control the Nevada-California Power Co., the Sierra Power Co., the Mono Power Co., and the Hydro-Electric Co. Ryan's attorneys deny this allegation but have refused to make their financial backing public.

PERSONALS

Walter L. Mulligan, manager of the United Electric Light Co., Springfield, Mass., was presented a large silver loving cup by the members of the United Electric Light Co.'s Employees' Relief Association on Dec. 19.

W. J. Kerr, for over three years chief draftsman for the Green Engineering Co., has become associated with W. A. Blonck & Co., manufacturers of boiler efficiency meters, and will have his headquarters at the main offices in the Fisher Building, Chicago, Ill.

*

Norway's Electrical Production—In Norway 12 years ago there was practically no production of electricity worth mentioning, but the horsepower now generated or being developed is approaching half a million. The practice has been to harness existing waterfalls or to dam natural lakes. Johan Haare, of Trondhjem, has worked out a completely new project which consists in the construction of an artificial lake as a reservoir for a small river, the Surna, in Nordmöre. The course of the river is to be altered by leading the water through a tunnel in a mountain a distance of two miles, thus obtaining a considerable fall. The electrical power station will be located at the lower end of this tunnel. About 50,000 hp. will be made available.

The Oregon Hydro-Electric Commission has completed its organization here and outlined a plan of procedure in its work which includes a study of every phase of production and utilization of electric power in the Northwest. The commission plans to make investigations in all counties where electric power is being developed from water power. It intends to urge Washington and Idaho to organize similar commissions and coöperate in the work, so that the problems of water-power development and application of electricity to manufacturing and other power purposes may be worked out. One of the largest projects to be investigated under the new commission is the canalization of the Snake and Columbia rivers, for improving navigation and developing hydro-electric power in large quantities. Idaho and Washington will be asked to coöperate in this survey, and the effort aimed at is to interest the Federal Government and devise methods whereby, along the rivers, districts may be organized to carry out the proposed power and navigation projects.

Duty to Safeguard Electric Wires—A company which maintains wires carrying deadly currents of electricity must use the highest degree of care to avoid injury to persons who, in their lawful employment, are liable to come in contact with them. "One who is brought by his employment in close proximity to electric wires, which are apparently insulated cannot be fairly charged with contributory negligence in coming in contact with the wires, unless the contact was the result of heedlessness or of his own lack of proper precautions for his safety." (Pennsylvania Supreme Court, Yeager vs. Edison Electric Co., 88 Atlantic Reporter 872.) An electric company whose wires were strung over a highway was bound to anticipate injury to one while driving a hay derrick along the highway, on account of the derrick coming in contact with an uninsulated wire, if it was previously a common practice for persons in the locality to drive derricks along public road. (Oregon Supreme Court, Greenwood vs. Eastern Oregon Light & Power Co., 136 Pacific Reporter 336).

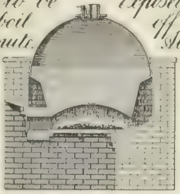
POWER

ol. 39 NEW YORK, JANUARY 20, 1914 No. 3

MILESTONES OF PROGRESS:-

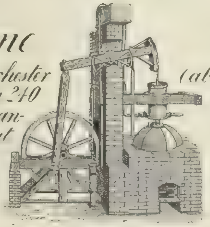
SOME QUOTATIONS FROM "FAREY ON THE STEAM ENGINE," PUBLISHED IN 1827, CONTRASTED WITH MODERN PRACTICE.

Boiler 1775



"Mr. Watt found that, with the most judiciously constructed furnaces, it required 180 sq. ft of heating surface to be exposed to the action of the fire, to boil off a cubic foot of water in a minute. At that rate 1 sq. ft. of surface will evaporate 3.6 cubic inches per minute. The boiler top was made of lead (about 1735) it is presumed this was used on account of the supposition that plates of iron, riveted together, could not be made sufficiently tight to contain steam."

Engine 1769



"In Manchester (about 1824) there are probably 240 large steam engines in manufactories exerting about 476 horsepower." This would give an average of 22.75 horsepower per engine, yet each machine was a massive structure.

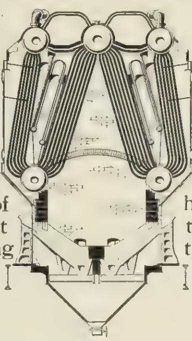
Walking Beam 1773

"The difficulty of procuring a tree of sufficient size to form the lever (Walking Beam) of a powerful engine (say 15 horsepower) in a single piece rendered it necessary in many cases to combine four or six beams into one."

8.4 lb. Coal = 1 hp.-hr. 1782

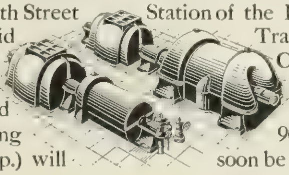
"The consumption of a bushel (84 lb.) of good Newcastle..... coals will supply (for one hour) an engine of 10 horsepower. And at the same rate, each horsepower will require 8.4 lb. of such coals per hour."

DELRAY BOILER—7400 HP.



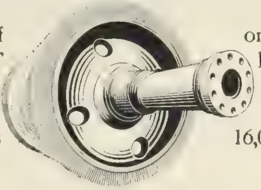
The Delray boilers at the Detroit Edison Co's station carry 200 lb. pressure (175 deg. F. superheat) and their furnaces burn 40 lb. coal per hr. per sq. ft. of grate at normal rating and evaporate 5.64 lb. water per hr. per sq. ft. of heating surface. Notice that they are of a "double" Stirling type, each boiler having two stokers.

COMPOUND TURBINE—30,000 KW.



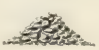
In the 74th Street Station of the Interborough Rapid Transit Co., New York City, three Westinghouse compound turbines aggregating 90,000 kw. (120,644 hp.) will soon be installed.

TURBINE ROTOR—150 TONS



The rotor of one of the "Imperator's" low pressure turbines weighs 150 tons, is of steel and transmits 16,000 hp.

0.93 LB. COAL=1 HP. - HR.



The angle compound engines and their low pressure turbines at the 59th Street Station of the Interborough Rapid Transit Co. operate on 1.25 lb. coal per kw. hr.

Bellevue Hospital Plant

By Thomas Wilson

SYNOPSIS—A plant of 28,000 boiler horsepower with complete coal and ash handling facilities. Steam is used for heating and cooking, in the laundry, in an absorption refrigerating plant and for other purposes common to hospitals. Current for lighting and power is supplied by the Edison Co.

⁂

Bellevue and Allied Hospitals of New York City, commonly conceded to be the largest institution of its kind in the world, covers a large area of ground, extending from Twenty-fifth to Twenty-ninth St., and from First Ave. to the East River. In all there are about 20 buildings, which vary in height from two stories in the older structures to six and seven stories in the new buildings, commonly referred to as the New Bellevue. The hospital is operated by the city, and is under the general supervision of Dr. George O'Hanlon.

For the various purposes for which steam is required in a hospital, large quantities were in demand, and more was needed after the completion of the late addition. There are practically 200,000 sq.ft. of radiating surface, large quantities of steam are required in the laundry, for cooking, sterilizing, disinfecting, for the large number of pumps supplying water for general use and for fire protection, for a steam elevator in the main building, for heating the charity dock, for supplying a 200-ton absorption refrigerating plant and for numerous other uses. It was necessary to install a new plant with sufficient capacity to supply all this steam, and, although this plant has been in operation nearly four years, it has never been given the attention in the technical press that its design and general layout would seem to warrant.

Primarily, the plant generates steam for heating and the other uses mentioned and takes no part in supplying current for lighting and power. Edison service is installed throughout the hospital and the load has recently averaged approximately 85,000 kw.-hr. per month. It will be considerably more when current is turned into all of the new buildings.

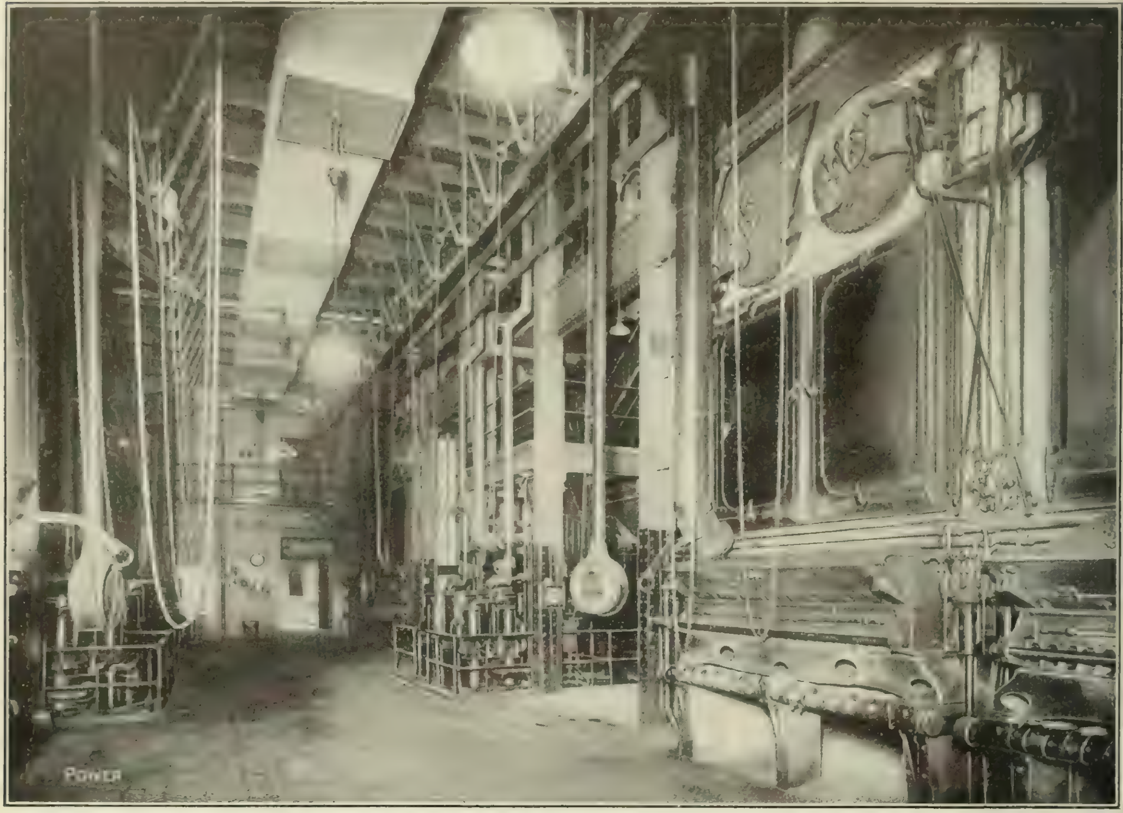


Fig. 1. View in Boiler Room at Bellevue Hospital

An inspection of the accompanying drawings will show that the boiler room is equipped with the latest devices to assist in its operation. There are, in all, eight 350-hp. B. & W. water-tube boilers arranged in batteries of two. The boilers operate at a pressure of 125 lb. and at times six of them have been put into commission to supply the heaviest demands. Other buildings are to be erected, however, and at their completion, practically the full boiler capacity will be required. Each boiler is

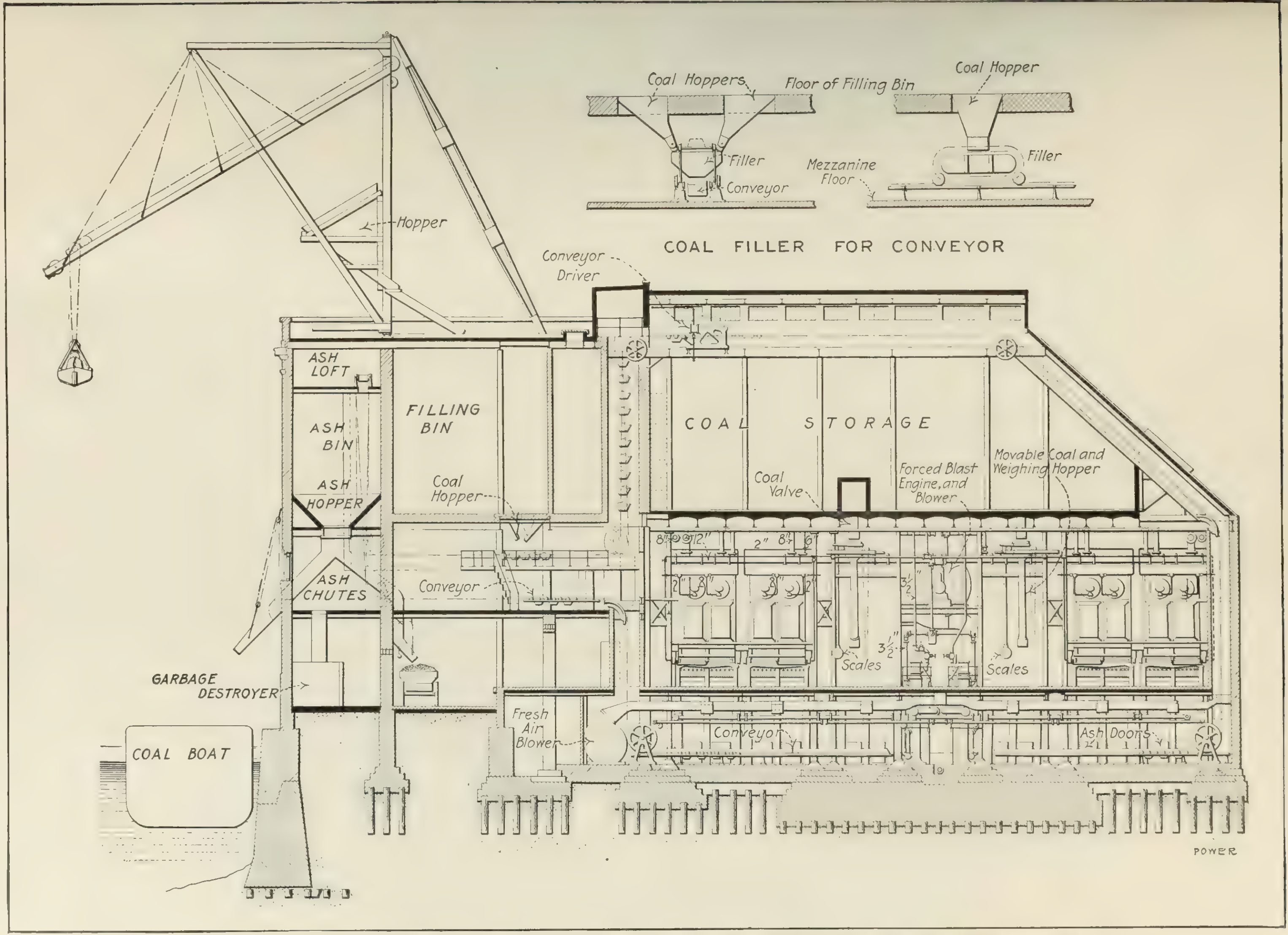


FIG. 2. LONGITUDINAL ELEVATION THROUGH BOILER ROOM, SHOWING METHOD OF HANDLING COAL AND ASH

equipped with a Wilkinson inclined grate stoker. It will probably be remembered that the grate of these stokers is made up of hollow bars which have an alternate forward motion of about $\frac{3}{4}$ in. produced by a hydraulic motor mounted on the face of the boiler. At the end of each grate bar, a small steam jet is inserted, and all the air or draft for the fire passes through the bars with the steam, issuing through openings in the steps of the grate. Blowers shown in the accompanying elevation force the air through a duct to the wind saddle at each boiler from which it passes through the grates to the furnace. Engine-driven blowers are also installed to force the draft when necessary. The products of combustion pass through a flue which drops to the basement floor and passes along to the stacks, of which there are two, each located midway between the two batteries of boilers on either side of the plant. The stacks are 7 ft. 6 in. inside diameter and ris 157 ft. above the grate level.

Handling Coal and Ash

No. 1 buckwheat coal is used as fuel, and it is all delivered by water. As much as 60 tons per 24 hr. is used in the winter months and varying with the weather conditions the coal consumption drops to 18 tons during the summer. It is elevated from a barge on the river by Hunt clamshell digger, the bucket of which has a capacity of 2800 lb. A double 10x12-in. engine operate the hoist and a 6x8-in. double engine drives the trolley From the bucket of the hoist the coal is delivered into receiving bin of 100 tons capacity, and from this bin it i discharged by gravity through an automatic filler into Hunt bucket conveyor carrying it to the main storag

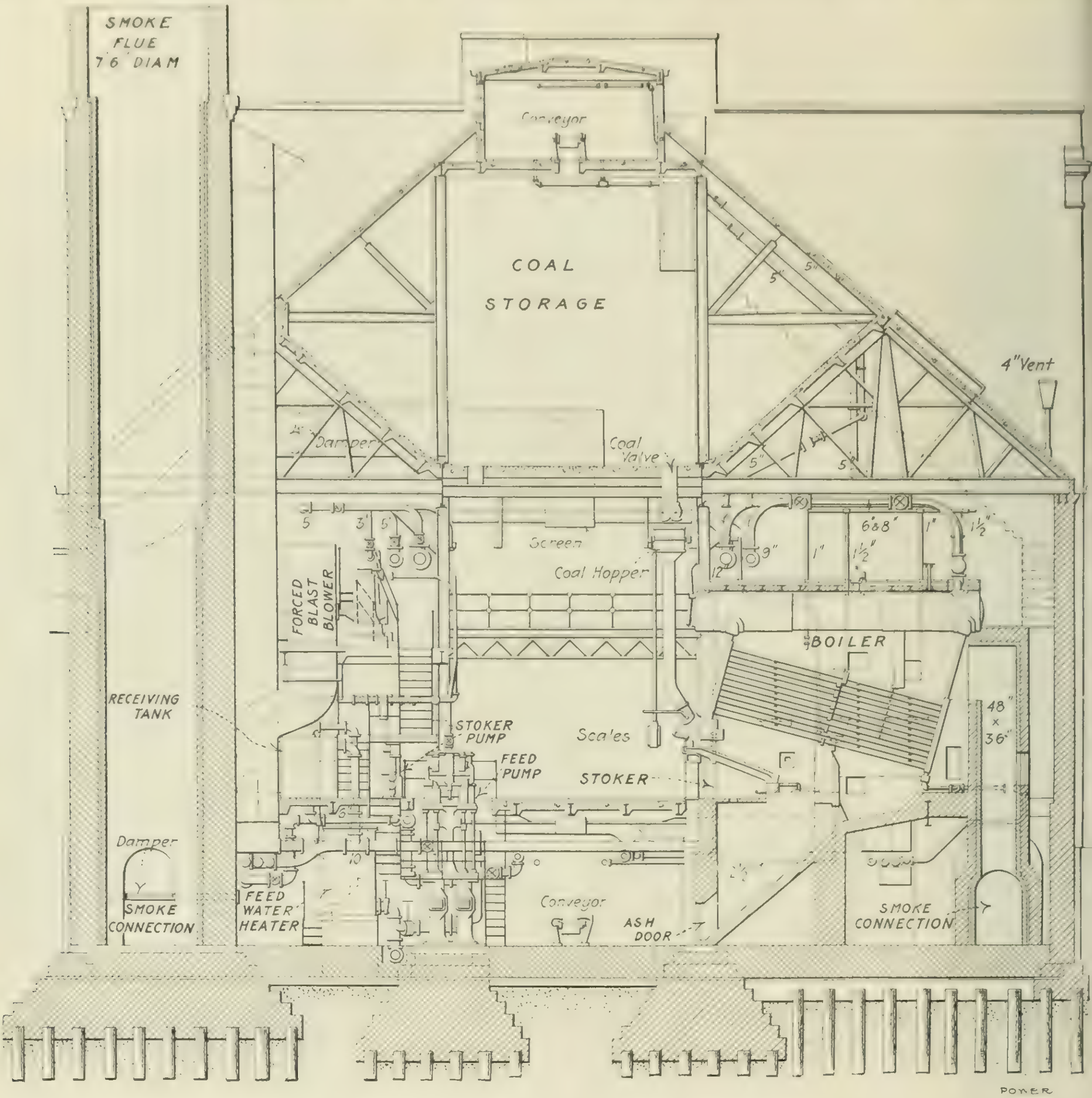


Fig. 3. Transverse Section through Boiler Room

bin over the boilers, which has a capacity of 3000 tons. In its passage from the storage to the hopper of the stoker, the coal is weighed in a hopper scales. These weights are recorded, and serve to check the first weighing, which takes place as the coal is delivered into the receiving bin, another scale being provided at this point.

The ashes are dumped from the dead plates of the stokers to receiving pits below each boiler. Unfortunately, there is little headroom in the basement, so that it is necessary to rake out the ashes from the pits onto the basement floor, cool and then shovel them into the conveyor which handles the coal. They are delivered into an ashbin under the hoisting-engine house, and from there chuted into contractors' wagons or into barges on the river.

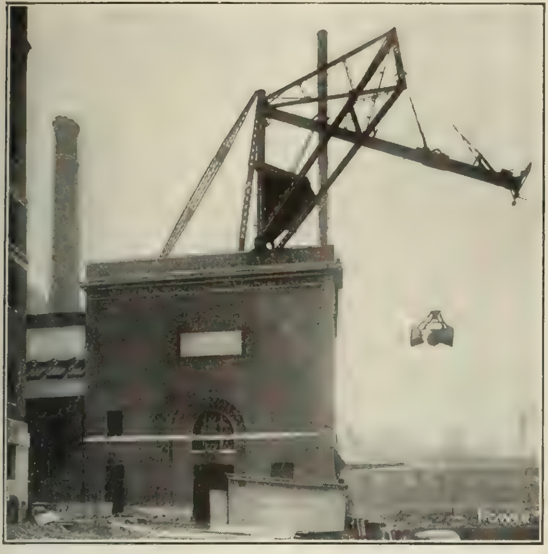


Fig. 4. Coal Hoist on Roof of Storage Building

Feed Water

During the colder months, the returns from the heating system form a large part of the feed water for the boilers. Makeup water comes from the city mains and on its way to the boilers it is raised in temperature to 208 deg. by Webster heaters. The feed pumps are of the Worthington Admiralty vertical type, and, as shown in the drawings, are placed midway between the batteries of boilers. In all, there are four pumps, 12, 17 and 8½ by 15 in. A ring system of piping allows any boiler to be fed by any one of the four pumps, and each pump can feed in either direction.

The water supply to the hospital is through two 12-in. mains, which enter the basement of the plant and are connected with filters, suction tanks, pumps and other appliances necessary to equip a central pumping station adequate for the entire property. It is thus evident that even the boiler water is filtered.

For general service, an Acme water-storage system, having a capacity of 60,000 gal., has been installed, and the plant may be adjusted so as to automatically maintain any pressure which is desired between 60 and 100 lb. to the square inch. The equipment includes a 40,000-gal. suction tank, eight water-pressure tanks, each with a capacity of 7875 gal., five air-pressure tanks located in the attic, with a combined capacity of 7350 cu.ft. The water pumps are four in number, steam driven and of the compound duplex type, with a capacity of 963 gal. per min. each. The air is supplied by two steam-driven air compressors, each having a capacity of 80 cu.ft. of air per min. against a pressure of 225 lb. As this system has been on the market for a number of years, its principles of working are probably familiar to all.

Three steam-driven Underwriter fire pumps, each with a capacity of 1000 gal. per min., furnish protection against fire. Naturally, all of these pumps are supplied with steam from the boiler room and in operation require no small amount.

Steam Supply

In supplying steam, the boilers feed into two ring mains, one an auxiliary to the other. Through taps from the mains, high-pressure steam is carried to the various buildings, a complete tunnel system being provided. At each point of supply a reducing valve connected between the two mains reduces the steam to 1 lb. pressure for the heating system. Two buildings are equipped with the Paul system, others have vacuum on the air line, and one building has a complete Webster system.

During the winter months, the double engines on the coal hoist operate on the average three days a week. On such days the exhaust is turned into the auxiliary main and is sufficient in quantity to heat three of the latest buildings. The balance of the heating is done by live steam. The long main acts as an accumulator, and distributes the supply over the nonoperating period of the hoist. When the hoist is in operation, it stores the steam at a pressure higher than that required in the buildings, and a sufficient quantity is stored to last until the next trip of the bucket.

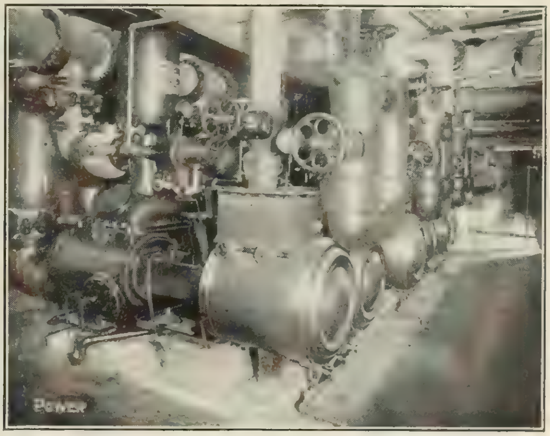


Fig. 5. Underwriter Fire Pumps and Pumps for General Service

All new buildings are provided with Johnson temperature control, and with full ventilating equipment, such as cheesecloth strainers, tempering coils and Johnson humidistats. In line with discussion that has been going on for the last year or two before hygienic and heating societies, the doctors have recently contended that window ventilation is better than artificial, so that this apparatus is inoperative at the present, but may be continued in service.

REFRIGERATING SYSTEM

In the hospital, refrigeration is required in the kitchens, in the morgue and for the storage of pathological specimens. Large quantities of ice are also used. At the present the refrigerating plant consists of two 100-ton York absorption machines, and space has been left for a third unit which will be needed when the ice tank has been installed and all of the new buildings are supplied with ice water for drinking purposes. As shown in the accompanying photograph and line drawing the apparatus is of the shell and coil type, with the usual vertical stands for the generator, analyzer and exchanger. Steam at 5 to 30 lb. pressure, depending on the temperature of the condensing water, is supplied from the boilers. With the exception of the condenser, which is of the atmospheric type and not of the new Shipley design, the plant is uptodate in every respect and is practically automatic in its operation. The condenser is 12 pipes high, 20 ft. long, and arranged on 25 stands. As usual 2-in. pipe is employed. The dehydrator is located on the roof just above the condenser.

Salt water is used for cooling purposes. It is drawn from the East River through Elliott strainers by either of two Blake and Knowles pumps, which against a head of 30 lb. will deliver 500 gal. per min. Each piece of apparatus requiring cooling water is supplied separately, and when the water has served its purpose it is discharged to the sewer. The plant is equipped with three strong aqua pumps, 20 and 12 by 8 in., with Burnham steam ends and York ammonia ends. Each pump is equipped with a Mason pump governor, a Rochester lubricator and an American revolution counter.

As the plant is of the absorption type, the brine system is employed. There are two brine coolers, one for each 100-ton plant. Calcium-chloride brine with a density of 1.230 is used, and 570 gal. per min. are cooled from a temperature of 15 to 10 deg. F. with cooling water at 80 deg. and steam at not over 30 lb. pressure in the generator. The brine is circulated by either of two pumps having a capacity of 250 gal. per min. against a head of 150 lb. The pumps are supplied with steam at 80 lb. pressure and each is equipped with a Richardson sight-feed oiler, a Mason governor and a Schaeffer & Budenberg revolution counter.

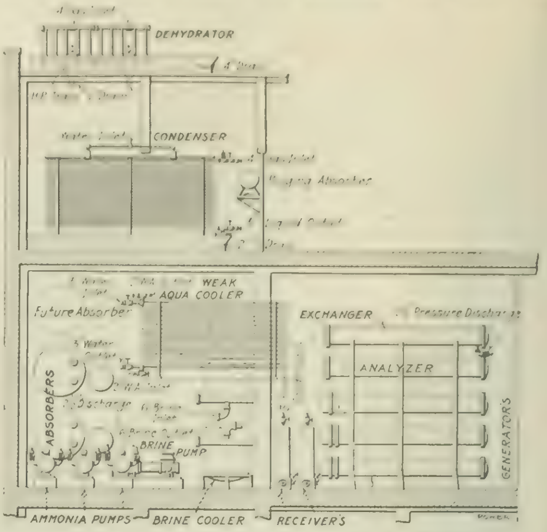


FIG. 8. LAYOUT OF REFRIGERATING PLANT

An unusually complete set of gages has been provided so that it is possible to know at a glance the pressure in

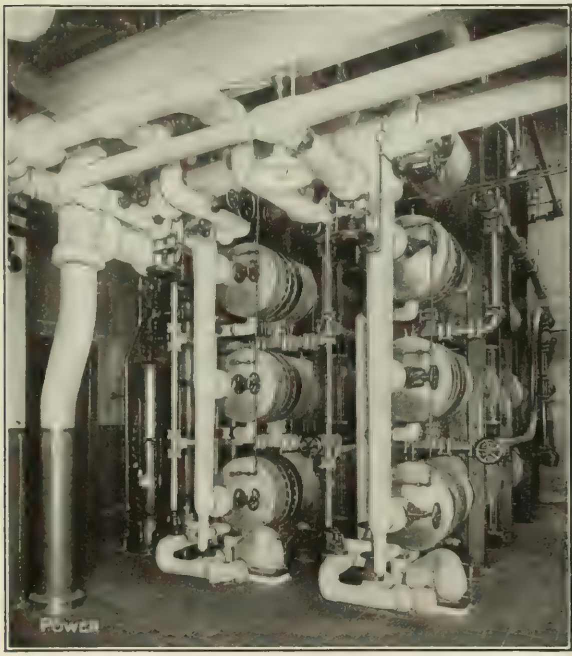


FIG. 6. TWO 100-TON ABSORPTION PLANTS

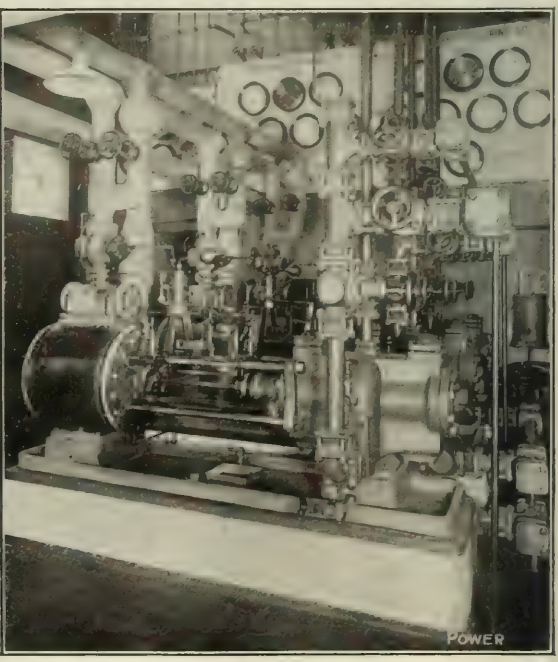


FIG. 7. THE THREE STRONG-LIQUOR PUMPS

any part of the system. There are gages for receiver pressure, generator pressure both ammonia and steam, absorber pressure and boiler-steam pressure. There are also a combination suction and pressure gage to show the pressures of the brine supply and return, a gage to show the salt-water suction pressure, and an eight-day clock.

We are indebted to McKim, Mead & White, architects for the plant, for the accompanying drawings, and much of the information was obtained from M. J. Harkins, supervising engineer of the hospital. For 14 years Mr. Harkins has been attached to Bellevue, and previous to this has had wide experience in marine and power-plant engineering. W. H. O'Neill is engineer in charge of the plant and W. T. Meinzer is operating engineer.

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Two Recent Southern Hydro-Electric Developments*

By George G. Shedd†

SYNOPSIS—Principal features of the Stevens Creek development of 31,000 hp. transmitting power to Augusta, Ga., and the Parr Shoals development of 29,000 hp. supplying power to Columbia, S. C.

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A development of 31,000 hp., ultimate capacity, known as the Stevens Creek development, is being built for the Georgia-Carolina Power Co. on the Savannah River, about eight miles above Augusta, Ga., to supply that locality, and another of 29,000 hp., ultimate capacity, known as the Parr Shoals development, is being built for the Parr Shoals Power Co. on the Broad River, about 27 miles above Columbia, S. C.

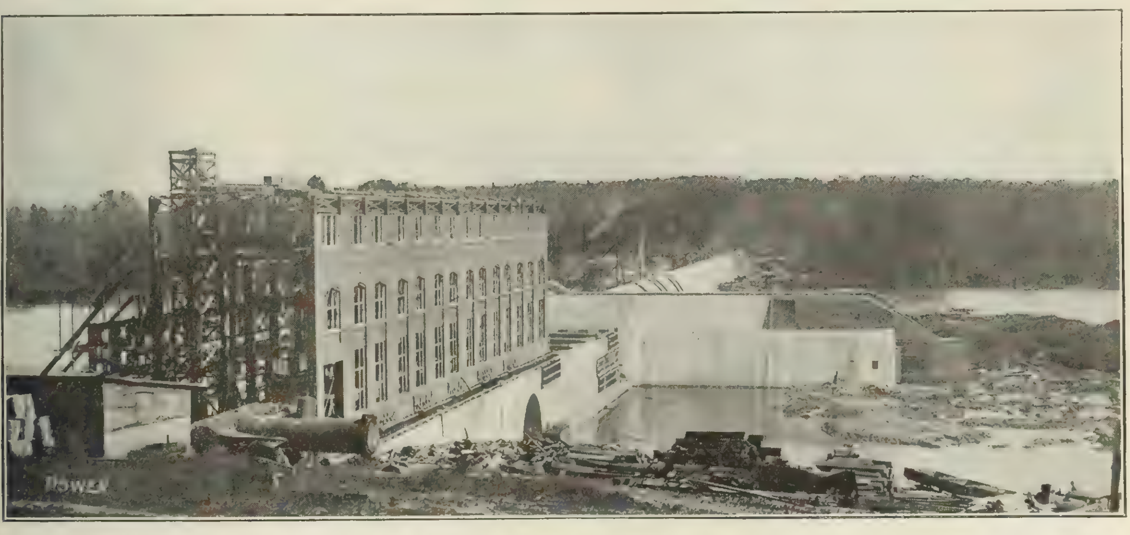

Fig. 1. General View of Stevens Creek Power House and Dam Just Prior to Completion

Stevens Creek Development

The location chosen for this development is just below the confluence of Stevens Creek with the Savannah River, and practically at the foot of a long series of rips in the main river. The average horsepower available has been computed for a period of 27 years, and on a basis of a load factor of 33⅓ per cent. was found to be very rarely less than 20,000 delivered horsepower.

General Description—The development consists of a dam, having a total length, including the power house, of 2700 ft., a power house designed for an ultimate equipment of 31,000 hp., with a present installation of 15,600 hp., and the lock, 30 ft. wide by 150 ft. long in the clear. A pond created by the dam extends about 14 miles up the Savannah River and about 13 miles up Stevens Creek, and will have a surface area of about 4200 acres.

Dam—The dam is of cyclopean concrete, the spillway section being 2000 ft. long of the ogee type, with an average height of 30 ft., and a maximum height of 47 ft. The nonoverflow sections have a combined length of 233 ft., with crest elevation 15 ft. higher than the spillway. The dam was designed to pass safely a freshet of 450,000 cubic feet per second, which is almost 50 per cent. larger than the greatest freshet on record.

In order to assist in operating flashboards on the dam, as well as to aid in taking care of water during construction, and to provide a means for complying with the government requirement that no water shall be stored, when the flow is below a certain specified limit, five sluice gates, 8x8 ft. each, with venturi settings are provided through the spillway section adjacent to the lock, and are operated at present by hand from a tunnel in the dam, although motors will be used in the future. Provision is made for the future use of flashboards, and sockets are also provided for guard pins, to safeguard the men when operating flashboards.

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*From a paper read before the American Association for the Advancement of Science, Atlanta, Dec. 30, 1913.

†Supervising engineer with the J. G. White Engineering Corporation.

Hydraulic Equipment—The turbines are being furnished by the I. P. Morris Co., and are of the vertical, single-runner, single-discharge type, 104 in. in diameter, set in a concrete spiral casing, and provided with concrete draft tubes; they will run normally at 75 r.p.m. The efficiency is expected to be better than 80 per cent. Each unit is provided with a double floating lever oil-operated governor, which can be controlled from the switchboard or by hand. A central oil-pumping pressure system is provided, working normally at 200 lb. The exciter turbines are rated at 450 hp. at 200 r.p.m., and are of a type similar to the main turbines.

Electrical Equipment—The electrical equipment of the first installation consists of five vertical Westinghouse revolving-field, three-phase, 60-cycle, 2300-volt generators rated at 2700 kv.-a., two 300-kw., 250-volt exciters and three 5400-kv.-a. transformers, stepping up from 2300 to 44,000 volts.

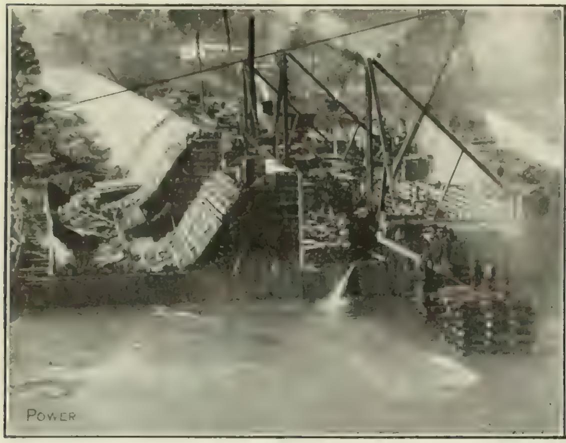

Fig. 2. Showing Method of Constructing Dam at Stevens Creek

Transmission Line—The transmission line to Augusta is approximately seven miles long, with galvanized-steel towers, designed for two circuits, with three wires on each side. The wire for the power circuits is No. 1/0, 17-strand, medium, hard-drawn copper, and the ground wire is $\frac{5}{16}$ in., seven-strand, copper-clad cable, having 30 per cent. conductivity. The power circuits have one complete transposition between the power house and the substation, and are hung on suspension-type insulators.

Substation—There is a substation at Augusta, which, on account of the limited ground space, was designed with two galleries. Here there will ultimately be installed in three banks of three each, 2000-kv.-a., single-phase transformers, stepping down from 44,000 to 13,000 volts. Only one bank of three transformers is at present installed. Provision is also made to step down from 13,000 volts to the existing circuits in Augusta of 2300 volts, two-phase. All of the switches in the substation are of remote control, and will be controlled from the switchboard in the steam station of the Augusta-Aiken Railway & Electric Co., which is adjacent to the substation.

Parr Shoals Development

The Parr Shoals development is located about 1½ miles upstream from Peak and Alston, S. C., and 27½ miles above Columbia. Based on past records, and a weekly load factor of 33⅓ per cent., the delivered power at Columbia will only occasionally be less than 20,000 hp.

General Description—The development consists principally of a dam, having a total length of about 2740 ft., including the power house, a power house 300x51 ft. in plan, a tailrace which is obtained simply by widening and deepening the original east river channel, a double-circuit steel-tower transmission line, 26 miles long, to Columbia, and a substation at Columbia.

The dam is of cyclopean concrete with the spillway section of the ogee type, 2000 ft. long, and an average height of about 39 ft.; the maximum height is 55 ft. A short section of nonoverflow dam, with its crest 15 ft. above the spillway, is constructed between the power house and the east shore, and a 15-ft. earth embankment, 300 ft. long, has been built on the west shore.

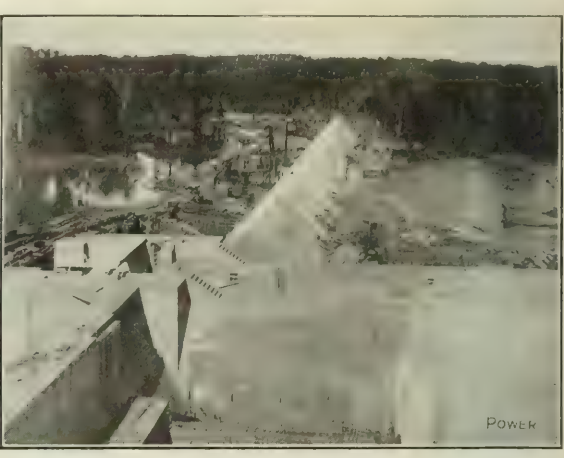

Fig. 3. Substructure of Power House at Stevens Creek

The dam contains six sluice gates adjacent to the power house, with a clear opening of 7x9 ft., each. These have a combined capacity of about 14,400 cu.ft. per sec., with head water at the crest of the dam, and tail water at normal level. The operating devices for the sluice gates are located within the dam, and the crest of the dam is fitted with the flashboard sockets, which will later be used for 5 ft. of flashboards.

Hydraulic Equipment—The turbines are of vertical, single-runner, downward-discharge type, 86 in. diameter, and have draft tubes molded in concrete and so proportioned that the velocity is gradually decreased to 5 ft. per sec. The flumes are controlled by large steel gates, hinged at the bottom, and operated by means of a traveling hoist, running on tracks on the head wall. The turbines are designed to run at a speed of 100 r.p.m. and will furnish 3600 b.hp. at 35-ft. head with an efficiency of 86 per cent.

The governors are located on the main floor and arranged to be controlled from the switchboard, although hand control is also provided. They are of the oil-pressure, double-floating-lever type, with a central oil-pumping and pressure system, operating normally at 165 lb. They are designed to control the speed within very narrow limits, and eliminate entirely any hunting or racing tendency which causes so much wear and tear on the gate rigging.

Electrical Apparatus—For the present the electrical equipment will consist principally of five revolving-field, three-phase, 40-cycle, 2300-volt, 3100-kv.-a. (at 75 per cent. power factor) generators, two 300-kw., 125-volt exciters and three three-phase transformers, each of 6200-kv.-a., stepping up from 2300 to 66,000 volts. Ultimately, eight units will be installed.

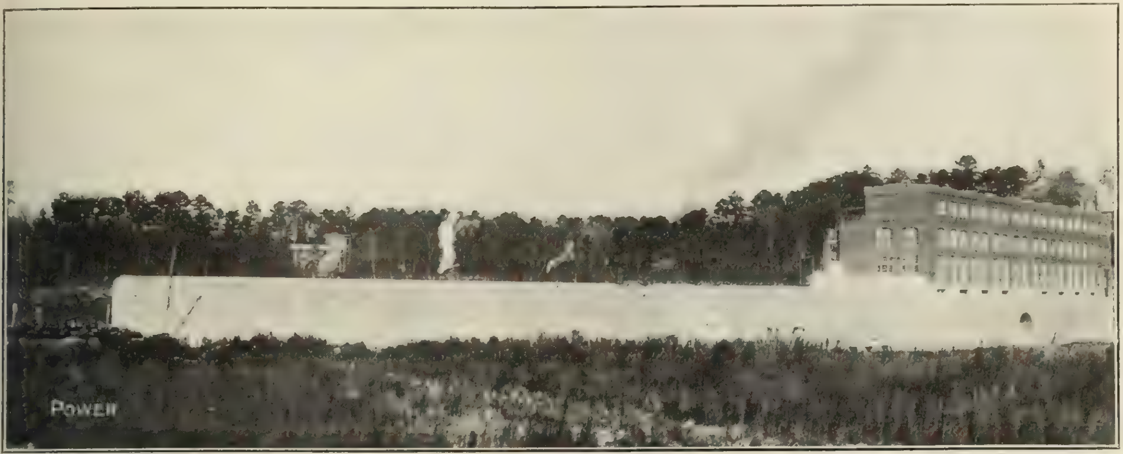

Fig. 4. General View of Parr Shoals Development from Down-Stream Side

Transmission Line—The transmission line is being built at present to Columbia, and consists of galvanized-steel, double-circuit towers carrying stranded medium-hard-drawn No. 1/0 copper wire.

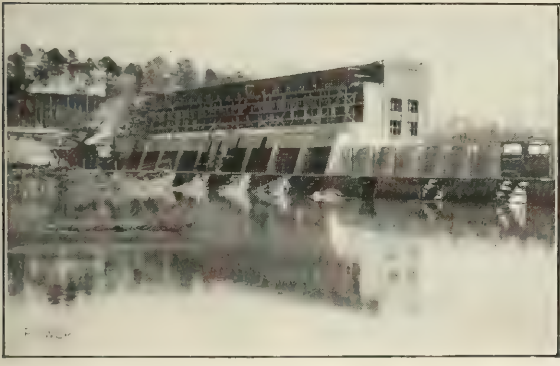

Fig. 5. Parr Shoals Power House and Dam from Up-Stream Side

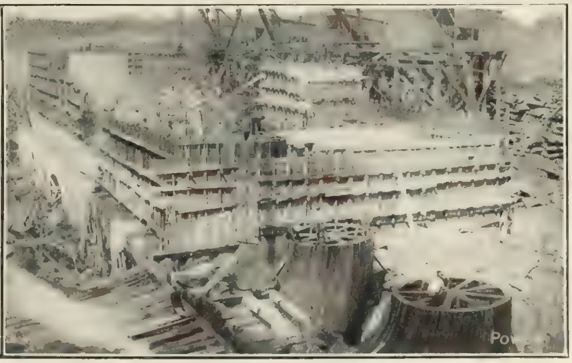

Fig. 6. Substructure and Forms for Draft Tubes at Parr Shoals Power House

Substation—A substation located in Columbia has been built, which will also act as a distributing station for the present hydro-electric plant and steam plant of the Columbia Railway, Gas & Electric Co. All the power generated by these two plants, and the plant at Parr Shoals will be distributed from this station. There will be two distributing voltages, 13,000 and 3400 volts, both 40-cycle, three-phase. The latter is the present distributing voltage and phase of the Columbia Railway, Gas & Electric Co.

Construction—Authorization to proceed with these two projects was received at about the same time in the latter part of June, 1912. Construction forces were immediately organized, camps built, wagon roads and railroads constructed in order to deliver material and construct the plant as cheaply as possible. As both projects were away from settlement of any size, it was necessary to provide accommodations for practically the entire force. At Stevens Creek the maximum number of men employed at one time was about 800 and at Parr Shoals about 1100, which, with the families, made a total population to provide for of about 1200 and 1500 people respectively. Great care was taken to safeguard the health of the camps, pure filtered water and sewerage systems being provided, and a hospital, fully equipped, with a resident physician always in attendance. As the Stevens Creek camp was only a mile or two from the intake of the Augusta water-works, additional precautions had to be taken to safeguard Augusta. For this reason incinerators were provided, and a filter bed used to purify wash water from the sewerage system. The wisdom of these precautions has been proved by the remarkable freedom from sickness in both camps. Malaria was very prevalent in the vicinity about both camps, but by using methods similar to those found so effective at Panama, this has given no trouble, except for the first few months at Stevens Creek. For the protection of the camp, a fire brigade was organized; telephones and electric lights were also provided, and to keep the men contented, athletic sports have been encouraged, such as baseball, football, tennis and trap shooting.

Preliminary to the construction of the dam a coffer dam was built, consisting of a series of rock-filled crib piers with 12-ft. openings between, which were later closed by stop logs, or open cribbing, with the upstream face sheathed and toe-filled. Later, and before the final closure was made, these openings were shot out, and the water passed through to the sluice gates and temporary openings which had been left in the dam for this purpose.

Quarries and sand pits were opened, and very efficient stone-crushing and concrete-mixing plants were set up, having a capacity of 1000 cu.yd. of well mixed concrete per day.

The general scheme adopted was, whenever possible, to start the various features of the work at such times as would bring their completion as nearly as possible to the date of delivering power. In this way one of the most expensive items, that of interest during construction, was reduced to a minimum. Work on the substructure of the power house was started first; then the sections of dam, containing sluice gates and temporary openings, followed by the main dam, substation, transmission line, power-house superstructure, and finally the power-house equipment.

It is expected that the Stevens Creek development will be ready to deliver power some time this month and the Parr Shoals development very shortly, which is only about a year and a half from the date of beginning work, a very short time for developments of this magnitude.

The entire work of engineering and construction on both projects, except the raising of the Southern Railway is being handled by the J. G. White Engineering Corporation, of New York.

* *

The Induction Motor--VI

By F. A. Annett

Commutator-Type Single-Phase Motors

The split-phase starting, single-phase induction motor can be successfully designed to meet certain requirements of service, such as constant speed, starting under loads that do not require large starting torque and where a large starting current is not objectionable. It, nevertheless, fails to meet the requirements for accelerating loads that demand a large starting torque with reasonable starting current, also for varying and adjustable speed service. To successfully meet this demand several types have been developed, each employing a commutator and known in general as commutator-type single-phase motors.

To those familiar with the direct-current machine, the series type of these single-phase motors will appear simple, but designing engineers have had many difficulties to overcome in successfully developing these alternating-current series motors, which have brought about many radical departures from the principles involved in the direct-current machine. Among these is the laminating of the field frame and poles to keep down the eddy currents set up by the action of the alternating flux, instead of solid cast-iron or steel as in the direct-current machine. Also, the number of coils on the armature is increased with a corresponding increase in the number of commutator bars; and high-resistance carbon brushes are used with a resistance connected in series with the coils on the armature between the coils and commutator bar. All this is to prevent sparking at the brushes due to the transformer action set up in the short-circuited coils under commutation, and a compensating winding placed in slots in the pole faces prevents armature distortion.

This type of series alternating-current motor possesses the same speed and torque characteristics as the direct-current series motor operating through wide ranges of speed and torque with no inherent speed regulation and if the load is removed the speed will increase without limit. On the other hand, if the load is increased the motor slows down very greatly with a large increase in torque. The chief application of this type of motor is for railway work and cranes, where the motor is continually under the guidance of an operator.

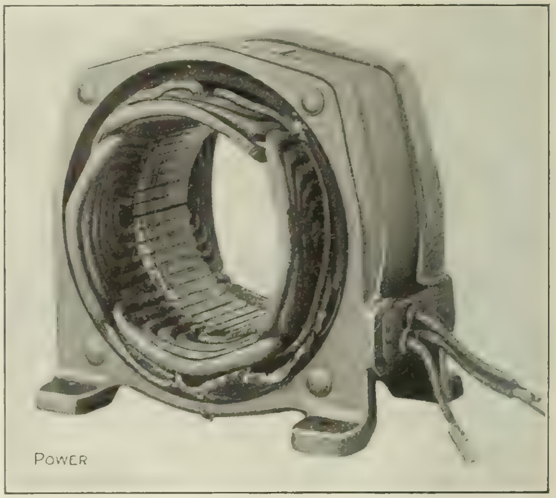

Fig. 53. Stator of G. E. Repulsion Motor

There are many classes of service demanding a motor having good speed regulation after being brought up to speed and with a torque which increases as the speed decreases or characteristics approaching the direct-current compound motor. Single-phase alternating-current motors of this type are usually known as repulsion induction motors. The stator is constructed very similar to the polyphase induction motor except that it has but one winding, concentrated so as to form distinct poles. Fig. 53 shows the complete stator of a G. E. riveted-frame repulsion induction motor. The rotor is constructed the same as the armature of a direct-current machine but instead of the armature current being supplied from an outside source as in the direct-current motor, the brushes are short-circuited and the current is induced in the rotor by the flux set up by the current supplied to the stator. The following will explain the action:

To understand a simple analysis of the repulsion motor it is necessary to keep in mind, first, the law governing the operation of an electric motor, which is, essentially, that a current passed through a wire in a magnetic field causes the wire to move at right angles to the lines of force, the direction of motion of the conductor depending upon the direction of the current in the conductor and the direction of the lines of force in the magnetic field. This is shown by reference to Fig. 54, *a* and *b*. In *a* is shown a conductor in a magnetic field the lines of force of which are passing from the north to the south pole, as indicated by the arrows. The conductor is carrying current down through the plane of the paper which sets up lines of force about it in a clockwise direction. This magnetic field set up about the conductor reacts upon the field from the polepieces and distorts it. This distortion tends to force the conductor to the left as indicated. If the current is reversed in the conductor as at *b*, flowing up through the plane of the paper, the lines of force set up about the conductor will be in an anti-clockwise direction. This will distort the lines of force from the polepieces in the opposite direction, and the motion of the conductor will be to the right.

The second rule to bear in mind is: When a varying magnetic field threads through a coil of wire it sets up an electromotive force that will cause a current to flow which is of opposite direction to that setting up the magnetic flux. This is shown in Fig. 55. Consider coil *a* connected to a source of alternating current and the current at the instant flowing in a direction as indicated by the arrowheads. This will set up a varying magnetic flux through the core of a polarity as shown, which will induce an e.m.f. in coil *b* opposite to that applied to coil *a*, and if the terminals of coil *b* are closed through a resistance *R*, a current will be set up in it in a direction opposite to the current in coil *a*.

In Fig. 56, consider a closed-coil armature between two field poles, the two field coils connected to a source of alternating current and the current at the instant in a direction to produce north and south poles, as shown. As the flux from the field poles thread through the armature coils it induces an e.m.f. in them opposite to that applied to the field coils, or in a direction shown by the arrow-heads, which indicates that the current in the field is flowing in one direction at the right-hand side and in the opposite direction at the left-hand side. The e.m.f. induced in the armature coils varies in value from zero at points *a* and *b* at the center of the polepieces to a maximum at points *c* and *d* between the polepieces, for at points *a* and *b* the flux divides and passes through each half of the armature coil, therefore, the coils at this point will have no lines of force threading through them, while coils at points *c* and *d* will have a maximum flux passing through them which will induce a maximum e.m.f. It will also be seen that the e.m.f. in the right-hand half of the armature is in opposition to that in the left-hand half so there will be no current set up in the coil, therefore no torque will be developed.

Now let the coils be connected to a commutator, as in Fig. 57, with brushes placed on the axis *ab* and connected together by a conductor *l*. This is the point of maximum e.m.f. across the armature. This current is flowing in the opposite direction under each half of the polepieces, and by referring to Fig. 54, it will be seen that the current under the right-hand half of the north pole (Fig. 57) produces a torque to the left; likewise under the left-hand half the current in the conductors is in a direction that produces a torque to the right, as shown by the curved arrows *t* and *t'*. The same condition exists under the south pole. From this it will be seen that, although a maximum current is set up in the conductors it is of such a direction that the torque developed in one-half of the armature is opposite to that developed in the other half, therefore, the turning effort cannot impart any motion to the armature.

If the brushes are placed on the axis *cd*, as in Fig. 58,

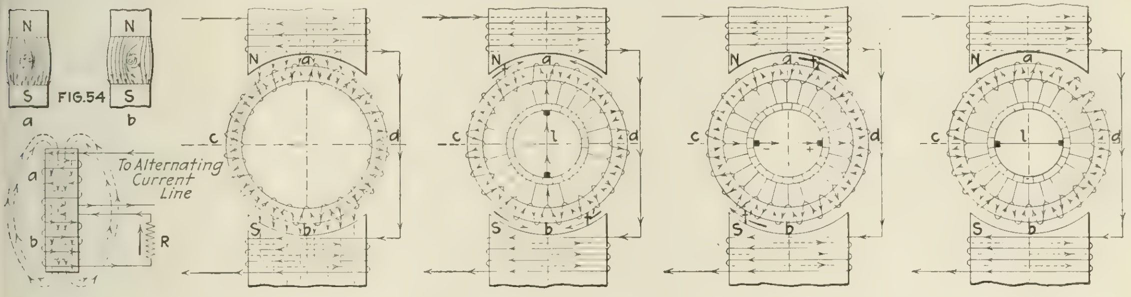

FIG. 54 FIG. 55 FIG. 56 FIG. 57 FIG. 58 FIG. 59

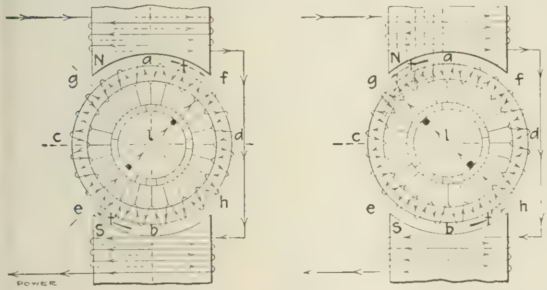

FIG. 60 FIG. 61

Figs. 54 to 61. Illustrating Current Actions in the Repulsion Motor and the current is supplied to the armature from an outside source, these brushes will be in a position to produce a maximum torque, for all the conductors under each pole are carrying current in the same direction. Consider the current at the instant of a direction as shown by the arrow heads. Again referring to Fig. 54, it will be seen that the current in the conductors in Fig. 58 is of such a direction as to produce a torque in a clockwise direction under both the north and south poles.

Consider again that the current in the armature conductors is set up by the induced e.m.f. produced by the varying magnetic flux from the polepieces and that the brushes are set on the axis *cd* and short-circuited by the conductor *l*, as shown in Fig. 59. It will be seen that no current will flow, for the e.m.f. induced in section *ac* of the armature is opposite to that induced in section *ad;* likewise, for sections *bc* and *bd;* that is, the e.m.f. at *c* is equal and opposite to the e.m.f. at *d*. Therefore, no current will flow in the armature conductors and no torque will be produced.

If the brushes are set at some intermediate point between the axis *ab* and *cd*, such as *ef*, Fig. 60, a current will be set up in the armature conductors of a direction shown by the arrow-heads. By referring to Fig. 56 and comparing the direction of the e.m.f. in the armature coils with that of the current in the armature coils in section *af* and *be*, Fig. 60, it will be seen that the current in *af* and *be* is opposite to the direction of the e.m.f. in a corresponding section of Fig. 56. This being true, the e.m.f. effective in setting up current through the brushes is that induced in sections *ae* and *bf* of the armature minus the e.m.f. induced in sections *af* and *be*, respectively. This is equal to the e.m.f. in the coils located between the point *eg* and *fh*, respectively.

By referring to Fig. 53 and applying Rule 1, to Fig. 60, it will be seen that the current under each polepiece is in a direction that will produce a torque as indicated by the curved arrows *t* and t^1. With reference to axis *ab*, this is in a direction with the lead of the brushes. This is true of all repulsion induction motors—they revolve in the direction that the brushes are shifted with reference to the axis of the field poles. All that is necessary to reverse the direction of rotation of the motor is to shift the brushes backward to the position *gh*, as in Fig. 61, and the current will be in a direction, as shown by the arrow-heads. By applying the rules for the movement of a conductor carrying a current in a magnetic field, it will be seen that the armature will turn in a anti-clockwise direction, as shown by the curved arrows.

This type of motor develops about 250 per cent. full-load starting torque for 250 per cent. full-load current when connected directly across the line, but if operated as a repulsion motor it has speed and torque characteristics of a series motor, which makes it unsuited for constant-speed service under varying loads; therefore, most all single-phase motors of this type are only started by the repulsion principle. After they have attained nearly synchronous speed a centrifugal device located in the interior or at one end of the rotor removes the brushes from the commutator and at the same time short-circuits the commutator segments, thus converting the machine into one that has the characteristics of a squirrel-cage motor and practically a constant speed from no load to full load.

Cyclical Changes of Temperature in a Gas-Engine Cylinder

In a paper read before the Institution of Civil Engineers on Dec. 16, Prof. E. G. Coker and W. A. Scoble gave an account of experimental work carried on during the past four years to determine the cyclical changes of temperature at the surface and in the walls of the cylinder of a gas engine; also the temperature of the explosive charge itself. The engine used for this investigation was of a standard type made by the National Gas Engine Co., and developed 12 hp. at 240 r.p.m.

The temperature measurements were made by means of thermo-electric couples with the inclusion in the circuit of a revolving contact-maker enabling the temperature to be determined at any point of the cycle. The surface metal temperatures and their cyclical changes were investigated at the centers of the inlet and exhaust valves, and at three points on a vertical diameter of the piston. Cast-iron plugs with their faces turned very thin were inserted at these points, and iron wires let through and riveted on the face of the metal to form the couples. The highest temperature found was at the center of the exhaust valve, this being 752 deg. F. The highest temperature at the inlet valve was 590 deg. F., and at the center of the piston, 644 deg. The cyclical change was greatest at the center of the piston, where, in one case with a minimum mixture and cold jacket, it was 176 deg. F. This large range was due principally to low temperature at the beginning of the suction stroke. A richer mixture or warmer jacket eliminated this low temperature and reduced the range to about 100 deg.

Values of $\frac{PV}{T}$ were calculated for several points on an expansion curve and found to be high at the explosion because the measured temperature was low; but they settled to consistent values near the middle of the working stroke.

The temperature of explosion was found to vary from 3300 to about 4000 deg. F., the latter value being obtained in a very rich mixture.

The cyclical variations of temperature in the exhaust pipe were also investigated. The maximum temperature during exhaust was found to be between 930 and 1020 deg. F.

In conclusion, it may be said that the temperature was governed mainly by that of the jacket water at outlet, and that the temperature drop along the barrel of the cylinder was very steep with rich mixtures, the latter effect being due to the high temperature of the metal surrounding the explosion chamber.

*

A Benevolent Fund has been established by the Institution of Mechanical Engineers of Great Britain, to give financial aid to prominent members who may through no fault of their own become destitute. A public meeting was recently held to arouse interest in the project and some $20,000 has already been contributed toward the fund. The plan of operation is to keep the fund invested and use the income only for the relief of deserving cases. It will be manifest that with 6000 members the income from a small fund will be sufficient to give substantial relief only in occasional isolated cases. It does at times happen, however, that engineers who have held high rank in the profession and to whom the profession as a whole may be largely indebted may in their declining years be placed in a position where the aid ordinarily afforded by friends and relatives in such cases is unavailable and the members of the profession itself ought to extend relief.

Elements of Heating

By E. N. Irwin

SYNOPSIS—Air, steam and water as mediums for the distribution of heat. Figuring the heat losses from a building and the radiating surface required.

⁂

The first forms of heating apparatus comprised open fire places and stoves of different types; but these were applicable to single, or at the most two or three, rooms. The heat of the fire was dissipated by radiation and to a limited extent by convection. The hot-air furnace was the next development to heat several rooms from one ire. For the reasons stated in the first article under the above title, the hot-air furnace is seldom used except for small installations, and here for the purpose of reducing the initial cost. Its bulk for a given capacity is comparatively great and the nature of the medium limits the efficient transmission of heat any distance. In larger installations, if the hot-air system is of ample capacity to do the work, there is little difference in the initial cost as compared with other forms of apparatus.

For all installations of any size water or steam apparatus is used with either direct or indirect radiation. Direct radiation as the name implies means radiators or any form of heating surface placed in the rooms to be heated. Indirect radiation is a special form intended to be placed at the base of a flue in order that air may be heated and passed into the room for ventilation. The air may be circulated by gravity or by mechanical means.

In all large installations where ventilation is required the latter is treated as a separate problem from the heating. This is especially true where the building is of a public or semi-public character where mechanical ventilation would be required only a few hours out of the 24. The buildings are heated by direct radiation and the air supply is operated only when the building is occupied. In dwellings and small buildings gravity air supply is used as a heating medium and to furnish ventilation at the same time.

In many factories the heating is accomplished by means of an air supply recirculated over indirect steam or water radiators. This method of heating is generally attractive due to the low initial cost. The major portion of the apparatus consists of the ducts, etc., and their cost is generally concealed in the builders' contract. The heating apparatus then comprises simply a fan heater, engine or motor and the immediate duct and steam connections to the fan heater and engine.

Direct-indirect radiation is a form of direct radiator placed in the room, with an air connection to the outside for ventilation. These radiators are provided with a box base and the heating surface is more or less jacketed in order that the outside air may be brought in contact with the surface of the radiator. Dampers are provided so that the air connection to the outside may be shut off and the air of the room recirculated. This is only a makeshift as far as ventilation is concerned, as the air supply is uncertain and inadequate, and the jacketing of the radiator destroys its efficiency as direct heating surface. In some cases the air current will be found to be from the room out of doors instead of inward.

The primary objects of a heating apparatus are to maintain the space to be heated at a livable temperature, say, 65 to 72 deg., regardless of the outside weather, and to transmit the greatest amount of heat per unit of surface in the shortest space of time with a minimum absorption of heat in raising the temperature of the apparatus and the heating medium.

Just as a radiator dissipates the heat of the heating medium to the rooms, the building radiates the heat to the outside. When the dissipation of the heat of the radiators exceeds that given off by the building the room temperature rises and when the rate per unit of time is less the room temperature drops. To maintain a constant temperature efficiently requires a medium that can be readily varied in temperature, and an apparatus and medium whose mass will absorb the minimum of heat for each temperature change.

In the temperate zone the outside temperature may vary from 70 deg. when no heating is required, to zero or even —20 deg., depending on the locality. All heating systems should include sufficient radiation to maintain the required room temperature in the coldest weather. Some engineers recommend somewhat less than the maximum due to the limited period of extreme weather. The few hours of maximum operation then require a higher temperature and pressure when steam is the medium and a higher temperature in the case of hot water. The source of heat, however, whether boiler or heater, must be capable of supplying the maximum requirements in heat units at the higher temperature of the medium.

TABLE 1. PERCENTAGE OF MAXIMUM LOAD AND NUMBER OF HOURS FOR EACH TEMPERATURE PERIOD

Temperature Period	Per Cent. Max. Load	Per Cent. of Season	Hours Each Period
0	100		
0 - 10	93	1.29	66
10 - 20	80	5.25	264
20 - 30	65	16.47	829
30 - 40	50	29 13	1471
40 - 50	25	22.49	1122
50 - 60	15	25.37	1275
		100.00	5027

Table 1 gives the percentage of the maximum requirements for each 10-deg. period in the vicinity of New York, as well as the percentage of time for each period in the entire heating season of about 5000 hr. The weather bureau reports giving the maximum and minimum daily temperatures were plotted on thermometer charts, and the total hours for each period determined.

Attention is called to the fact that there is considerable time even in January and February when the temperature is 40 to 50 deg. This table shows that the maximum load lasts only 1.3 per cent. of the time, and 75 per cent. of the time the demand for heat is less than one-half of the maximum in zero weather.

A heating system to be efficient should be capable of a wide range in temperature or capacity and quickly adjustable to suit varied requirements. Where the temperature of the medium is nearly constant, as in the case of low-pressure steam, the only method of varying the heat supply is by shutting off and turning on radiators either by hand or automatically. When the steam pressure may be varied though a considerable range, there is room for adjustment, as each variation in pressure changes the temperature of the medium.

Water can be varied in temperature through a range of 120 deg. and as a rapid change is possible at any distance if the circulation is forced, it makes the most desirable and efficient heating medium. Hot air can also be varied through a considerable range of temperature, but its specific heat limits its carrying capacity and makes the losses in transit excessive.

The first consideration in the design of any heating apparatus is the heat losses, expressed in B.t.u., from the building by radiation and leakage in extreme weather for the particular locality. In New York the lowest outside temperature is taken at zero and the following indoor temperatures are used in many cases, although in special manufacturing plants the owners generally specify the requirements.

TABLE 2 HEAT TRANSMITTED THROUGH VARIOUS KINDS OF SURFACES IN B.T.U. PER HR. PER SQ. FT.

Cooling Surface	Thickness Wall, In.	Difference in Temperature, deg. F													
		1	40	45	50	55	60	65	70	75	80	85	90	95	100
Solid Brick Walls	4	0.654	26.3	29.6	33	36.2	39.5	42.8	46.1	49.4	52.7	56	59.3	62.5	65.8
	8	0.458	18.3	20.6	23	25.2	27.5	29.8	32.1	34.4	36.2	39	41.3	43.6	45.8
	12	0.315	12.6	14.2	15.8	17.3	18.9	20.5	22	23.6	25.2	26.8	28.4	29.9	31.5
	16	0.258	10.3	11.6	12.9	14.2	15.5	16.8	18.1	19.4	20.6	21.9	23.2	24.5	25.8
	20	0.228	9.1	10.3	11.4	12.5	13.7	14.8	16	17.1	18.2	19.4	20.5	21.6	22.8
	24	0.194	7.76	8.73	9.7	10.7	11.6	12.6	13.6	14.6	15.5	16.5	17.5	18.4	19.4
Solid Stone Walls	12	0.45	18	20.2	22.5	24.8	27	29.2	31.5	33.8	36	38.2	40.5	42.7	45
	16	0.39	15.6	17.6	19.5	21.5	23.4	25.4	27.3	29.3	31.2	33.2	35.1	37	39
	20	0.35	14	15.8	17.5	19.3	21	22.8	24.5	26.3	28	29.8	31.5	33.2	35
	24	0.32	12.8	14.4	16	17.6	19.2	20.8	22.4	24	25.6	27.2	28.8	30.4	32
Solid Concrete Walls	2	0.85	34	38.2	42.5	46.7	51	55.2	59.5	63.7	68	72.2	76.5	80.7	85
	4	0.785	31.4	35.3	39.2	43.2	47.1	51	55	58.9	62.8	66.7	70.7	74.6	78.5
	6	0.56	22.4	25.2	28	30.8	33.6	36.4	39.2	42	44.8	47.6	50.4	53.2	56
	8	0.49	19.6	22	24.5	27	29.4	31.8	34.3	36.7	39.2	41.7	44.1	46.5	49
	10	0.42	16.8	18.9	21	23.1	25.2	27.3	29.4	31.5	33.6	35.7	37.8	39.9	42
	12	0.37	14.8	16.6	18.5	20.3	22.2	24	25.9	27.7	29.6	31.4	33.3	35.1	37
Wood Walls	Frame house con	0.29	11.6	13	14.5	16	17.4	18.8	20.3	21.7	23.2	24.6	26.1	27.5	29
	Factory building	0.24	9.6	10.8	12	13.2	14.4	15.6	16.8	18	19.2	20.4	21.6	22.8	24
	Factory building	0.46	18.4	20.7	23	25.3	27.6	30	32.2	34.5	36.8	39	41.3	43.7	46
Windows	Single	1.10	44	49.5	55	60.5	66	71.5	77	82.5	88	93.5	99	104.5	110
	Double	0.572	22.9	25.7	28.6	31.4	34.3	37.2	40	42.8	45.7	48.6	51.4	54.3	57
	Wire glass	1	40	45	50	55	60	65	70	75	80	85	90	95	100
Skylights	Single	1.03	41.2	46.4	51.5	56.7	61.8	67	72.2	77.3	82.4	87.6	92.7	97.8	103
	Double	0.621	24.8	28	31	34.1	37.2	40.4	43.4	46.6	49.7	52.8	55.8	59	62
Doors	65% w., 35% g.	0.572	22.9	25.7	28.6	31.4	34.3	37.2	40	42.8	45.7	48.6	51.4	54.3	57
	Plain	0.414	16.6	18.7	20.7	22.8	24.8	26.9	29	31.1	33.2	35.2	37.3	39.4	41.2
Floors	Joist with double floor	0.07	2.8	3.15	3.5	3.85	4.2	4.55	4.9	5.25	5.6	5.95	6.3	6.65	7
	Stone floor on arch	0.2	8	9	10	11	12	13	14	15	16	17	18	19	20
	Planks laid on earth	0.16	6.4	7.2	8	8.8	9.6	10.4	11.2	12	12.8	13.6	14.4	6.2	16
	Planks laid on asphalt	0.2	8	9	10	11	12	13	14	15	16	17	18	19	20
	Stones laid on earth	0.29	11.6	13.1	14.5	16	17.4	18.9	20.3	21.8	23.2	24.6	26.1	27.6	29
Ceilings	Joist with single floor	0.1	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
	Arches with air space	0.14	5.6	6.3	7	7.7	8.4	9.1	9.8	10.5	11.2	11.9	12.6	13.3	14
Roofs	Cor. iron with 4-in. framing	2.14	85.6	96.3	107	118	129	139	150	161	171	182	193	203	214
	Tile with 4-in. framing	1	40	45	50	55	60	65	70	75	80	85	90	95	100
	Copper on 1-in. framing	0.45	18	20.2	22.5	24.8	27	29.2	31.5	33.8	36	38.2	40.5	42.7	45
	Zinc on 1-in. framing	0.45	18	20.2	22.5	24.8	27	29.2	31.5	33.8	36	38.2	40.5	42.7	45
	Slate on 1-in. framing	0.43	17.2	19.4	21.5	23.6	25.8	28	30.1	32.2	34.4	36.6	38.7	41.8	43
	Asphalt	0.27	10.8	12.2	13.5	14.9	16.2	17.6	18.9	20.2	21.6	23	24.3	25.6	27

Office, schools and dwellings, 70 deg.; foundries, 50 deg. and generally intermittently operated; storage places, 50 deg. to prevent the sprinklers freezing; paint shops, 70 to 75 deg. with a dry atmosphere; machine shops, 65 to 70 deg.; textile mills, 70 deg. with a high degree of humidity.

The heat losses comprise the radiation of heat through walls, windows, skylights, floors and roofs. Only such portions of individual rooms are included as are exposed to lower temperatures than that of the room under consideration. Partitions and floors between rooms to be heated are not considered. Where floors or walls are below grade, the temperature of the ground should be taken at about 40 deg. instead of the lowest outside temperature. Air spaces in walls or under the roof and double windows with an air space reduce the losses by radiation by a considerable amount.

Table 2 gives the factors in B.t.u. per hour for different kinds of building construction for all temperature differences between the room and outside up to 100 deg. The construction of the building, as indicated on the plans, will determine what factors should be used in any particular case.

Many rules are given for estimating the amount of radiation and large percentages are added for leakage, exposure, prevailing winds, etc. These additions render the result merely an outside guess and will generally give too much radiation. Some use a ratio of radiating surface to cubic contents of the building based on the individual's experience. This is proper for the individua but is dangerous for others without experience.

It is the custom of the author to add nothing for exposure or prevailing winds. The sun may be obscured for long intervals and winds are liable to blow from any direction, so that these variables are as likely to affect one side of a building as another at different times. Where there is a likelihood for the exposure of the building affecting the heating of one side or section differently from another, the piping can be easily provided with contro valves so that the particular section may be regulated independently from the remainder of the building.

The accompanying form, used by the writer and shown near the top of page 91, includes all quantities used in the calculations for the radiation of a building. Thi can be filed for reference and used afterward in checking any part of the work. All rooms are given a number as well as the name generally indicated on the architect's plan. The cubic contents, glass surface and wall surface are determined and placed in the proper columns, as shown.

In place of adding for exposure the writer uses the column marked air change, giving the cubic contents o the room, which is multiplied by the factor in Table 4 for the proper temperature difference between the room and outside. These factors are the B.t.u. required to raise one cubic foot of air the number of degrees at the head of the column. The temperature outside is assumed

; —10 deg. and with the room at 70 deg. the factor ould be 1.64 B.t.u. for 80 deg. difference.

For all rooms under 4000 cu.ft. of volume, one change er hour is used and from 4000 to 10,000 cu.ft., one hange in two hours. The larger the room the greater the me estimated for the air change.

Job ... Floor Arch
City Owner Started
omputed By— State Date Finish

lass oom and No.	Exposure	Size	Cubic Contents	Air Change Cu.Ft.	Wall Sq. Ft.	Glass Sq. Ft.	Fl. Sq. Ft.	B.t.u. Losses					Air Supply				Direct Radiation			Ratio Rad to Cu. Cont.	
								Air Change	Wall	Glass	Floor or Roof	Total	Pupils No.	Air Changes per Hr.	Rise in Temp.	Cu.Ft. per Min.	Sq. Ft. on B.t.u. Basis	Sq. Ft Instld.	Type	B.t.u. Basis	Actual
12	N.E.	24x30x12	8640	4320	816	192	720	7085	14,851	16,896	4608	43,440	40		80°	1400	196	190	26″ single Col.-90 sec.	44	46
14	E.	24x20x12	5760	5000	352	128		8200	6,406	11,264	....	25,870	25	9.4	80°	900	117	120	38″ 2 col. 30 sec.	48	48
16	W.	24x20x12	5760	5000	352	128		8200	6,406	11,264	....	25,870	25	9.4	80°	900	117	120	38″ 2 col. 30 sec.	48	48
											Total	95,180									

ɛemarks and Factors Used:
Max. O.T. = —10°; I.T. = 70°; Av. temp. rad., 200; Trans. per deg., 1.7; Wall fac., 20″ brick, 18.2 B.t.u.; Glass fac., 88 B.t.u.; Roof fac., 21.6 ÷ 2; Floc fac., 6.4; B.t.u. per sq.ft. rad., 221; Air change 1.64 B.t.u. per cu.ft.

No. 12 is presumed to be a corner room with three sides exposed and with six windows, 8x4 ft., or 192 sq.ft. of glass. The wall surface is

$$(30 + 30 + 24) \times 12 = 1008 \textit{ sq.ft.}$$

$$1008 - 192 = 816 \textit{ sq.ft.}$$

of net wall. Room No. 12 will also have 720 sq.ft. of floor. All factors, as taken from Table 2, should be placed in the remarks space. The following B.t.u. losses can now be determined for this room and placed under the proper headings:

		B.t.u.
Air change	4320 × 1.64 =	7,085
Wall	816 × 18.2 =	14,851
Glass	192 × 88 =	16,896
Floof	720 × 6.4 =	4,608
	Total	43,440

Table 3 gives the transmission of radiation under different temperature conditions of room and heating surface. A flat transmission rate is used in this table of 1.7 B.t.u. per square foot per degree difference per hour. As the room is 70 deg. and the medium 200 deg. average, the radiation will transmit 221 B.t.u. per hr. By dividing the British thermal units per hour by 970.4, the condensation in pounds from and at 212 deg. is obtained, and by dividing the condensation by 34.5 gives the boiler horsepower required.

TABLE 3. HEAT UNITS EMITTED PER HR. PER SQ.FT. OF CAST-IRON RADIATION

Steam Pressure	Steam Temp.	Temperature of Room, Deg. F. 40	45	50	55	60	65	70	75	80	85	90	95	100
40	287	420	412	402	395	386	378	370	360	352	344	335	327	318
30	275	400	391	383	375	365	357	349	340	332	323	315	307	298
25	267	386	378	369	360	352	347	335	327	318	310	301	293	284
20	259	373	364	356	347	339	330	321	313	305	296	288	279	271
15	250	357	349	340	332	323	315	306	298	289	281	272	264	255
10	240	340	332	323	315	306	298	289	281	272	264	255	247	238
5	227	318	310	301	292	284	276	267	259	250	241	233	225	216
0	212	292	284	276	267	255	250	241	233	225	216	204	198	191
In Vacuum														
5½	200	272	264	255	247	238	230	221	213	204	196	187	177	170
10	190	255	247	238	230	221	213	204	196	187	177	170	162	153
13	180	238	230	221	213	204	196	187	177	170	162	153	145	136
18	170	221	213	204	196	181	177	170	162	153	145	136	128	119
19	160	204	196	187	177	170	162	153	145	136	128	119	110	102
21	150	187	177	170	162	153	145	136	128	119	110	102	94	85

Dividing the total B.t.u., 43,440 by 221 B.t.u. will give 196 sq.ft. of radiation. The last column headed "ratio cubic contents to radiation" is obtained by dividing the contents in cubic feet by the radiation in square feet. With sufficient experience it is possible by looking over the ratio column to detect any glaring error of judgment or calculation and this serves as a check on the work.

Cast-iron radiation is built in heights from 15 to 45 in. and from one column to five columns. Most radiators are standardized so there is little difference in the products of the different manufacturers. It is always best to obtain as good distribution as possible, and where it is impossible additional radiation should be provided. Cast-iron radiation well distributed will give up 1.7 B.t.u. per sq.ft. per hr. per deg. difference, but if wide high radiators are used this may be reduced to 1.5 B.t.u. If low radiators five loops wide are used they are as efficient as the narrow high radiator. Pipe coils and single-column radiators on temperatures averaging over 200 deg. will transmit 1.8 B.t.u. per deg. difference.

The rate of transmission depends largely on the velocity of the air over the outside and that of the medium within. The higher the temperature of the radiator the faster the air flows over the surface, and the more rapidly the medium is circulated through the radiator the greater the efficiency.

In estimating the radiation for gravity hot-water heating the drop for which the job is designed and the initial temperature will determine the average temperature of the radiation. If the system were planned for a 30-deg. drop and the maximum temperature is 190 deg. the average temperature of the radiation would be

$$\frac{190 + 160}{2} = 175 \textit{ deg.}$$

If the water was circulated in a closed system with 5 lb. pressure on the expansion tank, the outboard temperature could be 220 deg. without boiling the water out of the system. If the return was 200 deg. the drop would be 20 deg. and the average temperature 210 instead of 175 deg. The heater or boiler must have the same capacity in both cases, but the amount of radiation would be less as follows:

TABLE 4. HEAT UNITS PER CU.FT. OF AIR PER HOUR PER DEGREE DIFFERENCE OF TEMPERATURE BETWEEN ROOM AND OUTSIDE

Degree difference	30	35	40	45
Heat units	0.616	0.718	0.821	0.923
Degree difference	50	55	60	65
Heat units	1.026	1.129	1.231	1.334
Degree difference	70	75	80	
Heat units	1.436	1.539	1.641	
Degree difference	85	90	95	100
Heat units	1.744	1.847	1.949	2.052
Degree difference	110	120	130	140
Heat units	2.257	2.462	2.667	2.873
Degree difference	150	160	170	
Heat units	3.077	3.283	3.488	

$$\frac{(175 - 70) \times 1.6}{(210 - 70) \times 1.7} = \frac{168}{238} = 0.706 = 70.6 \textit{ per cent.}$$

Thus nearly 30 per cent. less radiation could be used, and in this case the amount of surface would be no more than for a steam system. The same results can be obtained with either system as far as varying the temperature is concerned, with the first cost considerably lower for the system employing high temperature.

Table 1 shows that 210 deg. would be required only 1.22 per cent. of the time, and if only one-half the heat were required 75 per cent. of the time, the water could be circulated at a temperature of 145 deg., giving a transmission of

$$(145 - 70) \times 1.6 = 120\ B.t.u.$$

per square foot of radiation, or one-half the maximum of 238 B.t.u. per hr. This calculation shows the fallacy of figuring the boiler power from the radiation, assuming a flat rate of condensation per square foot. The British thermal unit loss should be used for estimating the boiler power plus a certain amount, say, 10 per cent., for losses in radiation of mains, etc., if well covered. The boiler power will then be correct even if errors occur in figuring the radiation, although it is well to check the result by both methods.

In the accompanying form the example used was a classroom in a school. In most states the law requires a minimum of 30 cu.ft. per min. per pupil for air supply from outside and in some cases the same amount has to be exhausted. In case all the air is heated from the outside temperature to 70 deg., the cubic feet in the column under air supply can be totaled and the cubic feet per hour for the air supply determined by multiplying by 60 min. In this case the air is raised in temperature from —10 to 70 deg., and by multiplying by 80 and dividing by 55, the cubic feet of air 1 B.t.u. will raise 1 deg., the B.t.u. required will be obtained.

In the columns for air change and number of pupils the proper quantities are placed. In room No. 11 there are 25 pupils and 35 cu.ft. per min. is furnished for each, so that 875 cu.ft. of air, or in round numbers, 900 cu.ft., are provided. This air must be heated to 70 deg. from —10 deg. In room No. 12 there are 40 pupils and 1100 cu.ft. of air is required. Multiplying by 60 min. and 80 deg. and dividing by 55 gives the B.t.u. per hr. as 122,181, or 122,200.

In case the room is to be heated by an existing air supply for ventilation its temperature will have to be increased to do the work. In room No. 14 the air contents are changed

$$\frac{60 \times 900}{5760} = 9.4$$

times per hour. The B.t.u. required for heating are as given in the form, 25,870 per hr., and the number of degrees above 70 that the 900 cu.ft. of air must be raised will be

$$\frac{25{,}870 \times 55}{900 \times 60} = 26.3\ deg.$$

This means that the 900 cu.ft. per min. will have to be raised from —10 to 96.3 deg., or 106.3 deg. and the B.t.u. required will be

$$\frac{900 \times 106.3 \times 60}{55} = 104{,}367\ B.t.u.$$

It might be that if this were an isolated room and the balance of the air for the building were raised 96 deg. instead of 106, it would be proper to increase the air changes for this room purely to reduce the final temperature for heating. In case 15 changes per hour were desired, practically 1500 cu.ft. of air per min. would be required and the extra temperature for this would be

$$\tfrac{9}{15} \times 26.3 = 15.8\ deg.$$

The entering air would be at 85.8 instead of 96.3 deg. and the B.t.u. per hour required would be

$$\frac{1500 \times 95.8 \times 60}{55} = 156{,}763$$

instead of 104,367 B.t.u. The extra loss is generally overcome by arranging the ducts to recirculate the air of the room during nonsessions if there are many rooms heated in this manner. If the indoor air were recirculated the temperature drop would be 15.8 deg. in one case and 26.3 in the other. The heat loss would be the same as for direct radiation plus the loss for window leakage, or about 15 per cent. increase. It is plain why direct radiation is more economical for heating, especially in isolated rooms where little ventilation is required by the occupants. A restricted air supply with high entering temperatures increases the duct losses.

Another method in a case of this kind is to place an auxiliary indirect stack at the base of the flue for raising the temperature of the air before it enters the particular room. The stack is controlled automatically by a thermostat in the room. This method does not require a higher temperature for the air to the remainder of the building.

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Recent Court Decisions

Digested by A. L. H. STREET

Liability for Co-employee's Negligence—An employer is not responsible for injury to a workman, resulting from explosion of a boiler, due to the negligence of its engineer, if the injured worker was in the same general department as the engineer, unless the latter had been habitually so negligent or incompetent that the employer is blamable for retaining him. (Kentucky Court of Appeals, Wiltshire's Administratrix vs. Kister, 160 "Southwestern Reporter," 743.) [This principle does not apply under the Workmen's Compensation Acts nor in states where the "fellow-servant" doctrine is not applied.—Editor.]

Liability Concerning Open Ditches—A power company is not liable for injury to a horse through falling in an open ditch excavated by the company in a street, if the horse was running at large in violation of an ordinance. (Texas Court of Civil Appeals, Dallas Gas Co. vs. Wheat, 160 "Southwestern Reporter," 980.)

Right to Enjoin Diversion of Water—An owner of land bordering a channel on the eastern side of the Susquehanna River is entitled to enjoin a water and power company, which owned land on the western channel, from diverting water from the eastern channel by obstructions and dredging in the western channel, subject to the company's right to condemn the privilege. (Pennsylvania Supreme Court, Rider vs. York Haven Water & Power Co., 88 "Atlantic Reporter," 903.)

Duty to Insulate Wires—An electric company is liable for the death of a telephone company's subscriber, caused by the escape of a dangerous current from the electric company's wire to a nearby telephone wire at a point where the former wire was negligently permitted to remain uninsulated. (Kentucky Court of Appeals, Paducah Light & Power Co. vs. Parkman's Administrator, 160 "Southwestern Reporter," 931.)

Employer's Duty Concerning Boilers—An owner of a steam power plant owes it to his employees to maintain the boilers in a reasonably safe condition, and to warn them of any danger which they do not have reasonable opportunity to know. An employer was held liable for injuries sustained by plaintiff, an employee, under the following circumstances: Defendant employer maintained two boilers, which were side by side, and which were emptied through valves which connected with the same blow-off pipe, which extended outside the building. It was the plaintiff's duty every night to blow off the boiler which had been used during the preceding day. While blowing off a live boiler, and on opening the valve for that purpose, hot water and steam escaped from the valve of the other boiler, scalding the plaintiff. It was found that the plaintiff was not negligent in not noticing the condition of the boiler not in use. (Massachusetts Supreme Judicial Court, Perry vs. Webster Co., 103 "Northeastern Rep.," 379.)

Editorials

What Engineers Want to Know

As the annual reports of many central station-power companies show, nearly all have had a substantial business growth, particularly in current for power purposes. That much of the increased demand is from industries, too small to need plants of their own, is undoubtedly quite true. Still there are many large industries contracting for considerable current. For example: The Edison phonograph works in West Orange, N. J., has increased its purchased current 4700 horsepower during the past year. Not many months ago we were informed that the Maryland Steel Co. had contracted for 6000 horsepower for its Sparrows Point works. It is also reported that the American Steel and Wire Co., has been considering the use of purchased current for its three large works in Worcester, Mass., and that some of the large textile mills in southern New England may be supplied by recent hydro-electric developments.

When central stations increase their sale of current to small industries that would not be justified in maintaining their own plants, they are to be commended. What reason (or, shall we say, excuse?) is to be offered when industries, already using thousands of horsepower, contract for additional thousands? The cheapness of hydro-electric current is often a sound reason, but contracts for large quantities of current are more and more often being made with steam-driven central-station companies.

There are six main reasons why such contracts are made:

Because it actually pays to make them; because both owner and engineer are ignorant of the proper way to produce power; because the management is shortsighted and fails to coöperate with the engineer (as by using rattle-trap equipment with inevitable service interruptions); because of current-rate discrimination; because of lazy, incompetent engineers interested in their work only as a livelihood (and such men, though few, menace the welfare of their more conscientious brothers); and because of managers, who believe that the responsibility of a power plant is not compensated by the saving over purchased current.

What worth-while engineers want to know is how to meet the situation; how to make their present equipment enable them to compete with the power companies. Turbines, high vacuum machinery, superheated steam, etc., are conducive to high economy, but it would be folly to expect the owners of plants now in service to discard their present equipment or extensively remodel their plants, because this is so. Meanwhile the engineer must make the plant run at a cost so near the power company's bid that the owner will not sign a contract he perhaps will eventually regret.

Power has done, is doing and will continue to do all it can to help the engineer in this direction. Though let it be understood, as we have often stated, that when power can be bought for less than it can be made, and the service is continuous and constant, buy it by all means.

The Columbus Rate Case

In Columbus, Ohio, a taxpayer's suit is now pending in which the city officials having supervision over the municipal lighting plant are accused of rate discrimination in selling electricity below cost to private concerns and individuals.

There are many who believe the suit to have been instigated by the central-station interests, which are in competition with the city plant. Again, the plaintiff may represent isolated-plant interests or he may be a real altruist working upon his own initiative. The motive is of little consequence, the important question being whether discrimination exists; if it does, the case should be treated as would a private plant, for if some are getting electricity below the cost of production, the taxpayers are making up the difference. Unfortunately, figures were not submitted showing the actual cost of production and in the absence of these the plaintiff would have difficulty in proving a case.

It is easy to understand the attitude of the city officials. Briefly, their contention is that the plant having been built to supply electric-light service, the initial investment would have to be made for this purpose and the load would be at night only; therefore, any day load that might be taken on would be at an expenditure merely of fuel, water, attendance and additional maintenance.

This seems perfectly logical when viewed from one angle only. However, since the city has gone into the electrical supply business, it is just as logical to view the situation from a different angle and consider the day load paramount and the night load subordinate. According to the foregoing reasoning, the commercial load would then carry the fixed charges and the city would be charged a very low rate for street lighting. Obviously, both of these contentions are wrong and the only fair way is to make the municipal lighting plant a self-supporting enterprise, apportioning the fixed charges over the entire load and charging the city for its street lights just the same as any private customer.

The incapacity of the courts often to grasp such problems is strikingly illustrated in the decision on the first petition (see page 110) which states in part: "Upon what principle can the entire interest on the bonded debt be charged to the current furnished to private consumers? . . . If the amount furnished to private consumers is but a small part of the total current generated, and if that same portion should be charged with the burden of the interest on the bonds issued for building, equipping and enlarging the plant, it would stand little chance in competition with a privately owned plant which distributed that charge to the entire output."

We fail to see wherein the petition claimed that the whole interest on the bonded debt be charged to the electricity sold to private consumers.

The revised petition, which is now pending, is more specific than the first, and if properly interpreted by the court, the decision will go far toward defining the relation of municipal plants to the public.

Receipts and Recipes

Suppose a housekeeping paper were asked by one of its gentle readers to give her a recipe for a stove polish, and replied that, having accepted good money from the makers of the Rising Sun and Crumbs of Comfort brands for advertising their products, it could not conscientiously tell anybody how to make polish for herself.

Would the fair reader's estimate of the disinterestedness of the paper, and her respect for its advice and opinion, be enhanced or punctured?

Would a paper, the editorial policy of which was conducted along the lines indicated by this straw, win a strong, permanent, loyal constituency, and a reputation for unbiased opinion and disinterested advice?

An advertising patron of Power reproaches us because when a correspondent asked us for a recipe for something in his line, we gave him a receipt which everybody is at liberty to use, instead of telling him to buy the advertised goods. He says that our failure to do so indicates a lack of confidence in the goods which we advertise, and inferentially warns the inquirer not to use them, by recommending something which the editor evidently thinks is better.

Not at all! The fair delver into the mysteries of stove polish probably knows all about the Rising Sun and the Crumbs of Comfort. She knows that she could run around to the corner grocery and get a choice of brands, all nicely put up in pretty packages, with printed directions, and perhaps a coupon negotiable for a Morris chair when she gets enough of them. She does not want to be told that she can "learn of several reputable and, we believe, thoroughly efficacious brands by consulting our advertising columns." She wants to know how to make some; and it is up to the editor, the fountain head of all household knowledge, to tell her. Her curiosity satisfied, that may end it. She may even go so far as to mix up a batch, but when she finds that graphite at drug-store prices costs more than the nicely done-up package, coupon and all, and counts in carfare and bother, and what she gave away, and the soiling of her pretty hands, and the doubt if the effect is really as nice as that at which the darky mammy is grinning in the poster ad, she will go back to the ready-made article.

And this is the pith of the whole matter.

The ready-made article must be good. The success of the manufacturer, the permanency of his good will, the value of his business, all depend upon establishing and maintaining a reputation for excellence. And it must not cost so much more than something that one can make which will answer the purpose, that people will not buy it in preference to making their own. This does not mean that the price must be less than the materials can be bought for at retail; the user is willing to pay something for convenience and assured excellency. As a rule, the consumer will save time, money and temper by buying the prepared article, but if he wants to know how to make it himself it is the province of his paper to tell him.

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Factor of Safety

It is unfortunate, in some respects, that factors of safety are expressed in terms of the ultimate theoretical strength of the vessel or structure to which they are applied. It is largely on this account that the real significance of the safety factor is so often misunderstood, even among engineers, and the layman is usually dumbfounded at the extreme wastefulness of the engineer when he learns that a structure is designed to carry only one-fifth to one-tenth of the maximum load it is estimated to be capable of supporting.

The factor of safety has often been called a factor of ignorance, which is by no means justified, because a relatively small part of it is usually devoted to covering unknown conditions. While the ultimate strength of a structure may be five times the working strain, most engineers know that two or three times the working load on such a structure will usually produce deformations that are apparent to the eye, and of such extent that they would generally render its further use impractical.

While deformations of structure of such severity that they would become at once apparent are usually produced considerably below the actual breaking load, there are others that are not apparent to the eye but which are also extremely detrimental to the continued safe use of the structure and which are produced by loads more or less closely approaching the safe load.

For example, assume a boiler built of steel plate of 55,000 pounds tensile strength, the design being such that at 150 pounds working pressure the factor of safety i five; that is, the working load is 11,000 pounds.

A piece of this plate, tested in a machine for tensile strength, would probably show a permanent stretch a about 30,000 pounds, and in time would fail under thi load. It has been found that the working load must b considerably below this point of permanent stretch t prevent serious injury to the material, so we may say that if all strains were known to be just as they were calculated, for a boiler as described, and leaving out the question of uncertainty of the material as regarding assume values, the shell could not be expected to withstand strain of more than say, 22,000 pounds.

Under the assumed conditions our factor of safety ha dropped from five to only two, and this is all the margi left to care for the numerous unknown factors connecte with the variations in quality of material or maximur strains produced and is surely not enough to warrant th entire factor of safety being called a factor of ignoranc Boilers are run on a factor of safety of four, with fair degree of safety, but below this point the owner, an especially the operator, is skating on thin ice.

Those not accustomed to test materials have a vagu idea of the elastic stretch of material, such as boile plate, simply because the quantities dealt with are s small, but if an extended section under test is considere the realness of the stretch becomes apparent at once.

For instance, consider a 72-in. boiler, built for a working pressure of 150 pounds, a factor of safety of four, quadruple-riveted joint of 94 per cent. efficiency, assuming a tensile strength of 55,000 pounds for the materia The load on the shell material, due to a test pressur 50 per cent. higher than the operating pressure, would b 20,625 pounds per square inch on the net section between the rivet holes, and in the solid plate 19,38 pounds. A load of this amount would stretch steel abou 0.000645 times its own length, or the girth of a 72-i boiler 0.146 inches, which is measurable with a tape.

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The Index for Volume 38, the last half of Power fo 1913, is now ready. A postcard request gets you one.

Correspondence

Cause of Knocks in Pumps *

Referring to John Ferguson's letter on this subject in the Nov. 18 issue, page 727, I should like to add another important cause and its remedy.

Through wear shoulders are produced in both ends of the steam and water cylinders. The rings in the steam end and packing in the water end ride up on these shoulders and have a tendency to stick there. When the pressure is sufficient, the pump starts off with a jump.

To remedy this in the steam end, the only thing to do is to bore out the cylinder, and if the wear is excessive, put in new and larger rings and pistons. The shoulders should also be removed from the water end by boring. If this is not feasible at the time, it can be temporarily remedied by filling in the piston with small or old packing at either end and full-size new packing in the center.

The rings I use are made to fit and from the same material as is used in the square hydraulic packing. These I find very satisfactory.

For immediate relief in case of emergency, shorten the stroke of the pump, if it is so constructed that this can be done. To do this either move the tappit blocks nearer together or put on a leather washer in front of the tappit block on the side opposite to the one which is affected.

A. W. WILSON.

Sterling, Ill.

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Jacketing for Cylinders

Referring to Mr. Pearce's letter in Dec. 2 issue on use of soot for jacketing of cylinders, the heat-nonconducting efficiency of lampblack in comparison with other materials generally used for covering pipes was brought to notice by Prof. J. M. Ordway in a paper on "Nonconducting Coverings for Steam Pipes" before the American Society of Mechanical Engineers, to be found in Vol. VI, 1884-1885, of transactions of that society, page 168, etc. The paper includes results of experiments made in determination of the nonconducting properties of many combustible and noncombustible substances that might be turned to good advantage as coverings for pipes and cylinders of steam engines.

The relative conductivity of different materials was ascertained by taking one inch thickness of each placed on a flat surface of iron kept heated by steam to a temperature of 310 deg. F. and the pounds of water heated 10 deg. F. per hour through 1 sq.ft. of the substances gave for

Loose wool	8.1 lb. of water
Loose lamp black	9.8
Hair felt	10.3
Carded cotton wool	10.4
Air space alone	48
Fine asbestos	49

There is, however, considerable difference in texture between the light, finely divided material known as lampblack, which when produced commercially is commonly employed for imparting tint to paints, and the coarser deposit of ordinary coal or wood fire which goes by the name of "soot," and it is to be expected that there is a difference in their heat-transmitting capacities.

In a lecture before the Nottingham Guild of Mechanical and Electrical Engineers, Prof. Jacques Abady pointed out the relative loss of heat conductivity of boiler-heating surfaces due to different thicknesses of soot deposit by comparing the conductivity of clean pipes with that of soot-coated pipes, viz.:

	Loss Per Cent.
Clean pipe	0.00
$\frac{1}{32}$ in. coating of soot	9.5
$\frac{1}{16}$ in. coating of soot	26.2
$\frac{1}{8}$ in. coating of soot	45.2
$\frac{3}{4}$ in. coating of soot	69.0

From the above it can be seen that lampblack and the different coarser grades of deposit known as soot should be very good nonconducting materials for cylinder jacketing and for similar uses. Soot has a commercial value for many purposes, among others being extensively used as a "filler" for the material of hard-rubber goods, but its value in the arts need not deter its use for jacketing of cylinders as its principal cost is in the gathering, an item of expense that may be regarded as inconsiderable in any steam power plant where the material can be used with economy as a heat-nonconducting material for cylinder jacketing or steam-pipe covering.

The heat-resisting qualities of soot are readily appreciated on comparing radiation from an iron smoke uptake before and after it has been cleaned of soot and in view of this common experience it is rather surprising that a material so readily obtained is not more frequently employed for prevention of loss of heat from steam power-plant appliances.

H. S. MARDEN.

Fort Monroe, Va.

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Condenser-Tube Corrosion *

With regard to the correspondence in the issue of Nov. 11, on page 692, on the corrosion of condenser tubes, Mr. Chester states that it would seem that the quantity of ammonia and similar products of sewage works present in rivers is so small as to be negligible. Now, ammonia and ammonium salts when in solution in water become highly ionized and are thus very active in assisting corrosion; hence even when present in small quantities the effect of these constituents in assisting corrosion can hardly be disregarded. To illustrate this a simple chemical experiment might be carried out.

If a piece of zinc is placed in concentrated sulphuric acid it will not be dissolved, but if the acid is largely diluted by the addition of water it will be noted that the zinc dissolves quite readily. The reason for this is that the sulphuric acid when in solution in water becomes highly ionized and hence more active as a corroding agent.

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*"Power," Sept. 16, p. 404; Nov. 18, p. 727.

*"Power," Oct. 14, pp. 531-533; Nov. 11, p. 692; Dec. 2, p. 781; Dec. 9, p. 817.

The ability of acids to dissolve metals depends largely on their degree of ionization. When sea water is used as a cooling agent its most destructive constituent is perhaps magnesium chloride. Now, magnesium chloride in solution in water and under the influence of heat becomes dissociated into magnesium oxide and hydrochloric acid, thus:

$$MgCl_2 + H_2O = MgO + 2HCl$$

Now, as hydrochloric acid in solution in water is in a highly ionized state it forms an active reagent which attacks the tubes very readily. This is only an example of one constituent, but will serve to illustrate the grounds on which I state the opinion that the temperature may have a certain effect on the life of the tubes as is also stated in G. D. Bengough's report.

Mr. Chester's statement that his experience has led him to believe that the temperature has little or no effect on the rate of corrosion may be explained by the absence of impurities in the evolving water which would behave similarly to the magnesium chloride mentioned above. The above two points are open to discussion, but the remainder of the report and correspondence has been shown to be beyond argument.

John H. Geo. Morrison.

Glasgow, Scotland.

Cost of Power for Ice Making

On reading Mr. Brown's letter in Power of Dec. 23, one is led to believe that he champions the cause and course of central stations. I think he is inclined to beg the question, however. The telephone companies he mentions have so arranged their service that the report of a "busy wire" means that the firm or person called has been unwilling to incur the expense of sufficient apparatus to handle his individual business.

If a factory taking street current has too few motors to do its work, the central station cannot be blamed if it remains undone.

It is much more of a hardship for railroad companies to be limited to a fixed rate of transportation "plus service" than it would be for the central stations to be compelled to charge a fixed reasonable rate for current, for in the case of the railroads their rolling stock is not only useless during nonrush hours, but they are put to the extra expense of getting the unused cars, etc., out of the way and on to more or less expensive storage tracks.

Mr. Brown nicely says the central stations "are entitled to charge an adequate rate for service." No one doubts this, but the public is beginning to doubt the equity of the methods of arriving at the rates charged. If Mr. Brown is awake to the tendency of the times, he must have observed that it is becoming the custom more and more to frown on and forbid the furnishing of similar articles or service, at the same time and place, to different buyers, at different prices. It cannot be denied that one of the questionable practices of central stations is to charge the highest rates they are able to squeeze from their customers unless their customers think and have the means to install an isolated plant.

If any ice-making plant (located where good coal may be bought for, say, $3 per ton) is paying more than about 1¼c. per kw.-hr., it is not doing as well as it should. The writer has knowledge of a plant using sawdust for fuel that is making clear ice with less than 12 lb. of sawdust per hour per ton of ice made per day, which may be equivalent to about 2¼ lb. of coal.

If any central station will sell current at approximately the above cost, it would be advisable for an ice manufacturer to close the contract. If it will not, see what others are doing and endeavor to do as well.

Paul Bigelow.

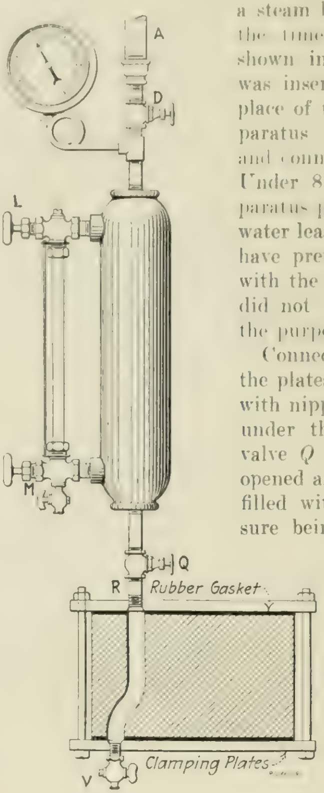
New York City.

Testing Valve for Leakage

A short time ago it was necessary to test a valve for leaks, which was designed to work under vacuum. A pressure pump was not available. As there were 24 ports spaced 2 in. apart, a leak between two ports in the center of the casting, if it were a small one, would hardly be noticed at the end of a port, so we had to use water.

Nothing else being available I took a water column off a steam boiler not in service at the time and connected it as shown in the sketch. A plug was inserted in the valve *Q* in place of the nipple *R*. The apparatus was filled with water and connected to the air line *A*. Under 85 lb. pressure the apparatus proved tight, at least no water leaks were visible. I would have preferred to test with air with the valve under water, but did not have even a barrel for the purpose.

Connection was then make to the plates by replacing the plug with nipple *R*. Gaskets were put under the plates. The globe valve *Q* and the drain *V* were opened and the port to be tested filled with water, the air pressure being turned on to make sure that the port was full.



Testing Outfit

There was 85 lb. air pressure on the gage, and the water high in the glass. The valves *L*, *M* and *Q* were opened and the drip cock closed. To see how the pressure held I closed valve *D*, and the pressure remained the same. I then closed the valve *L* at the top of the water glass and left the bottom valve *M* open. To my surprise the gage pressure began to drop and the water in the glass dropped out of sight while the pressure was falling off from 85 to 70 lb. Opening valve *L* the water came back in the glass to the original level; then closing it the water dropped out of sight in the glass with a further drop in pressure. There were no leaks that I could find either of water or air. This same thing would happen on every port out of the 24 tested.

Two days later the casting came back after being machined to be retested, and there was no evidence of leaks. I tried the same experiment with the valve *L* and the water slowly rose until it filled the glass, with only a slight drop in pressure. What I would like to find out is, why the water in the glass went down in the first test. I have asked several mechanics and they are as badly at sea as myself.

J. F. McRae.

Chicago, Ill.

Orsat or CO_2 Recorder*

A. Pohlman, in his article (Nov. 25) on the above subject, says: "When a man manages a plant, he should, whenever possible and consistent with efficient operation, keep the cost of producing power at a minimum."

This statement is somewhat contradictory because it opposes "efficient operation" to "keeping the cost of power at a minimum." If we interpret Mr. Pohlman's meaning right, it is this: That a man in charge of a steam plant should strive to reduce the cost of power (increase the efficiency) at the lowest cost for apparatus to bring this about. That is a commendable principle. Mr. Pohlman, however, is in error when he says that: "The tendency now is to analyze fuel gases only so long as is necessary to determine the changes required to bring the boiler up to the highest possible efficiency obtainable under local conditions, and then disregard the gases entirely except for an occasional checking up."

The present tendency is toward closer control of boiler-house operations, and especially of the process of combustion. Those who have given the problem of boiler-room economy most attention have found that sporadic analyses of the flue gas are quite inadequate to maintain maximum efficiency.

Mr. Pohlman cannot have given the problem very serious or logical consideration; otherwise he would not draw a parallel between the engine and the boiler in the way he does. The two have little or nothing in common.

If the boilers are adequate, the engine receives the required steam at a practically uniform pressure. It runs at a uniform speed, the steam consumption is automatically regulated to the load, there are practically no variables to contend with, the valves having been correctly set, by the aid of an indicator, and other minor adjustments made, an efficiency peculiar to the engine and its load will result, and continue for weeks and months. There is very little or nothing that the attendant can do to better it. Mr. Pohlman is therefore quite right, so far as the engine is concerned, an occasional set of indicator cards is all that is required to enable one to keep the engine at normal efficiency.

It is far from true, however, that an occasional analysis of the flue gases is sufficient to assure the economic operation of a steam boiler. The boiler is operated on variables so to speak. The fuel bed varies from minute to minute. The coal may vary from nearly all coarse to mostly fine in an hour, where soft coal is used, and with the cheaper grades of anthracite, it is nothing unusual to have the ash vary from 12 per cent. to 20 per cent. and more in successive carloads. The same holds true for soft-coal screenings.

The furnace conditions are entirely different just before and after cleaning the fire. This change of condition from the best to the worst takes place gradually in the course of a few hours. And on top of all this a fluctuating demand for steam must be met by the boilers. There are numerous other variables that influence the operation of a boiler which need not be mentioned here.

Mr. Pohlman says: "Do with your boiler as you would with your steam engine. An indicator is used on an engine to locate trouble, and after adjustments are made, that ends the use of the indicator for the time." What adjustments does Mr. Pohlman propose to make to meet these variables in the operation of a boiler once for all? Can permanent adjustments be made to meet these conditions at all?

From the parallel which Mr. Pohlman draws between the boiler and engine, we must infer that those little things are not worth bothering about, for he says: "An indicator is used on an engine to locate trouble, and after adjustments are made that ends the use of the indicator for the time."

Applying this principle to the boiler it means simply this, that so long as the required steam is forthcoming and there is no kick from headquarters about the coal bills, there is no occasion for gas analyses, but when the supply of steam falls short or is kept up with increasing difficulty or the coal bills begin to incite adverse comment, bring out your Orsat, make a few analyses to locate the trouble, effect the necessary adjustments, then put it away until trouble again calls for its use. And this, Mr. Pohlman says, is the present tendency in the practice of gas analyses in power plants. The outlook for marked improvement in boiler efficiency would be dubious if it were true.

Mr. Pohlman agrees, however, that a recording CO_2 meter would be preferable to an Orsat. The writer admits that a hand apparatus is better than nothing, but it must be used regularly, not merely to correct manifest trouble, but to anticipate trouble, to detect air infiltration and to improve the methods of firing. It may also be admitted that there are a large number of small steam plants, and even larger plants, that are irregularly or intermittently operated where a recording CO_2 meter would not pay, but there is not one steam plant in a hundred developing 250 hp. or over, running 10 hr. or more a day and 300 days per year, in which recording CO_2 meters would not be a paying investment, provided proper attention is paid to them and the information which they give. Even a cheap hand apparatus is a poor investment unless it is regularly and intelligently used.

E. A. Uehling.

Passaic, N. J.

All on Account of a Mouse

While passing the switchboard, I heard an unusual sound like that of a vibrator of an induction coil and it was evidently coming from somewhere behind the switchboard. Four lead-covered cables coming from two 2200-volt alternating-current generators are led to the switchboard through a 4-in. drain tile laid in cement and sealed with cement at the ends where the cables come out. The cables are taken through a small square hole in the floor of the switchboard platform and through this hole I could see a dim flash whenever the sound occurred. I also thought I could smell hot insulation.

I proceeded at once to tear up the floor, and in doing so disturbed the cables so that the noise practically stopped. Thinking the flash was only some static disturbance, due to excessive damp weather, I went home, instructing the night engineer to watch closely.

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*"Power," July 29, p. 176; Sept 2, p. 344; Sept. 16, p. 406; Oct. 14, p. 545; Oct. 28, p. 613; Nov 25, p. 761

Nothing developed during the night and when, the next morning, I proceeded to investigate, everything looked all right, but when I ran my hand down the cables to the point where they emerged from the tile, I found a dead mouse, head and shoulders out of a hole in the cement. Pulling it out, I found the left shoulder burned to the bone.

A closer investigation showed that the lead and rubber insulation had been gnawed from one wire from each machine, only one of which was running.

W. G. Greenlees.

El Campo, Tex.

⁂

Jam Nuts*

In the Nov. 25 issue, page 761, L. C. Tucker says in regard to my former communication: "Any good lathe hand can make a nut which has no lost motion." This is not so, for as long as the nut can be turned on the thread it can be shown with instruments of precision that there is always some lost motion. Machine tools have not yet attained perfection.

What was under consideration was ordinarily good machine work and with such work there is sufficient lost motion in nuts to affect the adjustment of journals, such as of a large marine-engine crankshaft, which if adjusted by the nut next the cap, and then a jam nut is set up against that nut, there is likely to be some music.

Charles H. Manning.

Manchester, N. H.

⁂

Failure of Piston-Rod Riveting

I have read with interest the account, page 735, Nov. 18, on the above subject, also your editorial, page 725, with which I entirely agree. Riveting of this sort, as suggested, has to be taken largely upon faith, and for that reason should not be depended upon when serious damage may result from sudden failure.

A short time ago I had an experience with failure of a riveted piston rod under conditions which may possibly be considered as more exacting than those referred to, though involving less risk of personal injury. One of the steam hammers under my charge gave out, the piston and rod parting. This was originally of the usual riveted type, the break taking place close to the piston. To save delay while another forging was obtained I had the piston bored out and recessed for riveting in the manner of the repair described, and had the piston shrunk on and well riveted over. This worked for less than two hours, the rivet head shearing off at a sharp corner which had been left at the bottom of the recess made in the piston for the rivet head. On making a second attempt I had the corner rounded off. The job then proved satisfactory and we have continued the use of the repair, although extra parts have been ready for some time. Experiences of this kind have made me somewhat careful of accepting any form of riveting for dangerous service.

As suggested by your editorial, too much work of this kind is put out for no other purpose than the saving of a few cents, or from lack of appreciation of the risks that are taken. The efficiency of cold riveting is always doubtful and such work should not be accepted without careful inspection of the job before and after riveting.

Judging from the description of the piston-rod riveting referred to, page 735, the original job should have been refused on account of insufficient rivet head.

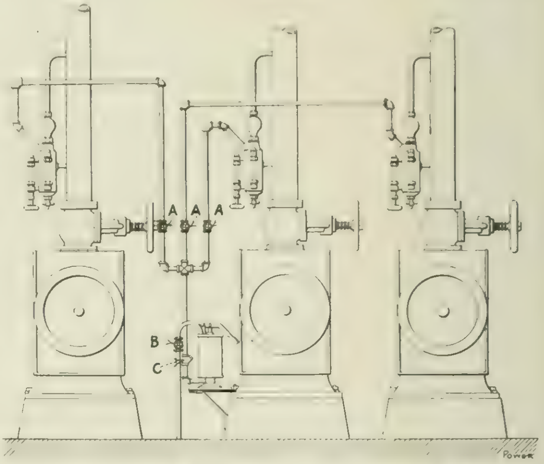
Fred P. Strachan.

Belfast, Ireland.

⁂

Lubricators Filled from Force Pump

In the plant where I am employed we have a lubricating kink that for cleanliness and time saving is hard to beat. The illustration shows three lubricators, connected to a 1-gal. hand pump by a ¼-in. pipe. Globe valves *AAA* in branch lines from the pump are to be kept closed at all times except when in use; *B* is a globe valve in the supply pipe to the pump and *C* is a check valve in the main discharge line from the pump.



Lubricators Filled from Central Pump

The operation of filling the lubricator is to close all globe valves except one in the branch leading to the lubricator about to be filled, open this valve and work the pump until the lubricator is full of oil. The time and trouble of draining the lubricator is dispensed with as the oil forces the water into the steam main. The flow of the water into the steam line is so slow that it is not noticeable in the cylinder. This device can be attached to any number of lubricators any distance from the pump. Each lubricator has the top of the filler plug sawed off, tapped and threaded for ¼-in. pipe.

F. B. Dunbar.

Pueblo, Colo.

⁂

Running Cross-Compound Engine on Light Load

H. Rollins, in the Dec. 9 issue, asks for different views on operating cross-compound condensing engines under light loads. I was much interested in his letter. It is a difficult matter to comment on the operation of another's plant unless one is familiar with the conditions. Evidently the plants discussed were not equipped as mine is. A receiver should properly be equipped with a trap, the discharge of which should be open to the atmosphere and where it can be seen.

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*"Power," June 24, 1913, p. 910; Sept. 9, p. 375; Oct. 7, p. 515; Oct. 28, p. 612; Nov. 25, p. 761.

As to operating under light loads with a vacuum in the receiver, it has been my experience that it could not be done for the reason that as soon as the trap fills with water it will open the discharge to the atmosphere and there will be a rush of air through the trap and water seal into the receiver and on being admitted to the low-pressure cylinder and condenser this will break the vacuum. With the vacuum gone a pressure will be created in the receiver, causing the trap to discharge and drain the receiver. In reference to the danger of carrying a receiver pressure causing the low-pressure cylinder to do the work and the high-pressure piston to draw water from the receiver, while there is a pressure in the receiver and the trap is working properly there would be no water in the receiver for the high-pressure piston to draw. Again, with no receiver pressure, when the trap opened to discharge, the water would flow through the trap and keep the receiver drained.

There should be a relief or safety valve between the high- and low-pressure cylinders ample enough to take care of any excess pressure that might occur from accident to valve motion or reheaters.

The writer has never experienced any trouble with water in either cylinder, but has lost the vacuum due to air rushing through the trap into the receiver. Since that time I have always carried 2 or 3 lb. receiver pressure on light loads. I might state that my condensers are of the barometric type and perhaps more sensitive than others in handling air leaks.

H. Moore.

Milwaukee, Wis.

* * *

Compound Engines on Light Loads

Discussion along the lines suggested by H. Rollins, in the Dec. 9 issue, relative to running cross-compound engines on light loads, will, no doubt, be beneficial to all.

Receivers should be equipped with a safety valve and trap. There should be a live-steam line connected to the receiver through a pressure-reducing valve for the purpose of supplying steam direct from the boilers to the low-pressure side, that the engine may be operated from that side alone if necessary. The safety valve should be set to blow at about 5 lb. above the pressure maintained by the reducing valve and it should be large enough to take care of a sudden inrush of steam from any source. The trap should be connected to the lowest point in the receiver and the discharge should never be under higher pressure than that of the atmosphere. Some traps have an internal bypass, but with this type, as well as others, it is better, even though a few more valves are required, to have a bypass around the trap the full size of the other connections.

In one plant where the writer was employed, this trap served a twofold purpose; that of draining the receiver and the low-pressure cylinder as well when the engine was not in operation.

All of the four engines were connected through one exhaust line to two condensers, so when any of the engines were shut down the exhaust valves were closed and as they may be required for service at any time, a 1-in. bypass around the high-pressure throttle valve was partly open at all times, maintaining about 2 lb. pressure on both cylinders and receivers, holding the air out of the system, as well as keeping the engine warm. The elbow in the line leading from the low-pressure cylinder to the exhaust line was connected through a drip to the intake side of the trap. The valve on this drip line was close to the *L* and was closed when the engine was in operation. When the engine was shut down this valve was open, permitting the trap to take care of the low-pressure cylinder condensation under the above conditions. Without this drain the cylinder would fill with water and the purpose of the steam bypass would be defeated.

About five minutes before starting, unless the engine was needed quickly, the trap-bypass valve was opened, also the throttle-bypass valve and all of the water blown out of the cylinders and receiver. Then the valve on the low-pressure drip line was closed, also the bypass on the trap, and before opening the exhaust valve the three-way indicator-connection valve was opened to first one end of the cylinder and then the other, blowing out the air in the system, especially when not kept warm as mentioned above. We would then increase the supply of circulating water to the condenser, after which the exhaust valve would be opened and the engine started with the vacuum on the receiver.

Under these operating conditions the vacuum on the system would remain constant when starting the idle engine, while if the same engine was started up practically cold and without blowing the air out of the cylinders and receiver the vacuum would drop at times, as much as 10 in.

Of course, we run with the vacuum on the receiver for only a short time, and I would not recommend this method of running for any length of time, even though the receiver could be drained, for under these operating conditions lubrication of the low-pressure cylinder is practically impossible and a scored cylinder may result.

On light loads we always shortened the cutoff on the low-pressure side by manipulating the adjustment provided for that purpose on cross-compound engines of the Corliss type, maintaining a receiver pressure of one or two pounds. However, the low-pressure cylinder was not doing all the work, as suggested in Mr. Rollins' article, for the high-pressure side supplied the steam to keep up the receiver pressure.

I note in the article referred to above that one engineer runs his engine during the noon hour with all the drips open and a vacuum in the receiver. I doubt very much the practicability of this method if more than one engine is served by the same condenser, unless they are all working on the same load. The opening of the drains on one might admit air to the system, reduce the vacuum and interfere with the working of the other engines.

A. K. Vradenburgh.

Albany, N. Y.

* * *

Correction: In the résumé of "Condenser-Tube Corrosion," in the Dec. 16, 1913, issue, the author is misquoted on page 844, about the middle of the first column. The sentence reads: "The speed of the cooling water through it should not be less than 100 ft. per min. to prevent *salts* from depositing on the tubes." In place of the word "salts" it should read "any particles of solid matter."

Inquiries of General Interest

Wet and Dry Return Pipes—In a gravity steam-heating system, what is the difference between wet and dry returns?

C. W. R.

A wet return pipe is one which is below the water line of the system while a dry return is one which is mainly above the water line.

Pump Efficiency—What is the efficiency of a pump based upon?

S. K.

The efficiency of a pump is the ratio of the actual work performed in foot-pounds of output of the pump to the number of foot-pounds of power required to be applied to the pump.

Difference between Gases and Vapors—What is the distinction between gases and vapors?

C. B.

Under ordinary temperatures and pressures, if the temperture of a gas is kept constant its pressure may be increased by decreasing its volume, whereas vapors exist only with a definite pressure corresponding to each temperature.

Meaning of "Air Bound"—What is meant by the statement that a pipe, radiator, trap, pump, or other steam-plant appliance is "air bound?

C. C.

That air or gases that may have been liberated from water, or by condensation of steam are present in pockets, or completely fill the pipe or appliance, and interfere with its proper operation.

Reseating Slide Valve—How can a leaky steam slide valve of an air compressor be repaired?

S. C.

If the valve or seat is badly cut and worn, its faces should be machine planed and scraped true and tight. If only slightly worn the faces can be filed and scraped, but filing or scraping should not be attempted except by one who is skilled in the operation.

Relative Heat-Transmission Differences—What are the relative heat-transmitting efficiencies of boiler plates and tubes of different thicknesses

A. C. L.

The conductivity decreases with their thickness, but the absolute difference is so small for thickness ordinarily employed as to have no appreciable effect on the rate of conduction and transmission of heat through clean boiler plates or tubes of different thicknesses.

Compression in Low-Pressure Cylinder—Is there any advantage of compression of exhaust in the low-pressure cylinder of a compound engine?

E. P.

In running a compound engine, compression is equally as beneficial in the low-pressure as in the high-pressure cylinder for filling the clearance space with exhaust steam compressed to nearly admission pressure and in contributing a cushioning effect on the reciprocating action of the engine.

Relieving High-Pressure Steam Line—How can water of condensation forming in a high-pressure steam line be returned to a boiler without using a pump or injector?

D. C. G.

If the steam line is high enough above the boiler for the pressure, due to the head of water in a drip taken out of the line to be in excess of boiler pressure, the condensate may be returned to the boiler as in an ordinary gravity-return steam-heating apparatus. Or, the water of condensation may be returned to the boiler by a steam loop. See "Power," page 1633, Sept. 13, 1910.

Lap of Steel Stack Joints—For greater durability, how should the girth joints of a steel stack be lapped?

A. F. D.

Steel smokestacks best withstand the corrosive action of the weather and last longer when each course is entered into the course below it. When the courses are entered inside of those above, soot sifts from the inside of the stack down through the joints, and finding its way to the exterior surface when moistened causes discoloring streaks and rapid corrosion.

Advantage of Intercooling in Compressing Air—What are the advantages of compressing air with intercooling?

J. D.

Principally in reduction of power required for compression. By intercooling, the air is delivered by the first cylinder against lower pressure, there is less waste due to clearance and therefore somewhat greater amount of air per stroke is taken into the compressor. The more efficient the intercooler, the greater the reduction of strains, less loss of power from friction and more uniform air resistance in the compressor.

Cleaning Boiler of Oil—What method should be followed to thoroughly clean a 100-hp. return-tubular boiler of oil?

B. R.

The boiler should be cut out of service and when cooled it should be emptied. After introducing two or three pailfuls of soda ash, the boiler should be filled with water and gently fired for 12 to 15 hours, keeping the steam pressure between 10 and 15 lb. A portion of the water may be run off at intervals and be replaced by feeding clean water. At the end of the "cooking" period the boiler should be allowed to cool and emptied and the interior should be well rinsed with clean water.

Efficiency and Friction Horsepower—A steam engine drives a direct-connected pump, the output of which is 190 hp., with a mechanical efficiency of 85 per cent. If the indicated horsepower of the engine is 250, what is its mechanical efficiency and what is the friction horsepower?

J. P. C.

The net power developed by the engine and received by the pump is

$$\frac{190\text{ hp.}}{0.85} = 223.53\text{ hp.}$$

and the mechanical efficiency of the engine is

$$\frac{223.53}{250} = 0.8941,\text{ or } 89.41\text{ per cent.}$$

The pump friction is

$$223.53 - 190 = 33.53.$$

The engine friction is

$$250 - 223.53 = 26.47\text{ hp.}$$

Therefore, the total friction is

$$33.53 + 26.47,\text{ or } 60\text{ hp.}$$

Economy of Coal vs. Wood as Fuel—What would be the saving by the use of average good coal for boiler fuel at $6.50 per ton of 2000 lb. in place of cut-and-dried jack pine, costing $5 per cord?

J. L. S.

The calorific value of dry wood is about 8250 B.t.u. per lb. A cord of commercial dry firewood weighs about 2000 lb. and contains about 25 per cent. weight of water; hence the calorific value of the cord wood would be about 75 per cent. of 8250, or 6187 B.t.u. per lb. Evaporation of the moisture and its expulsion at the temperature of the chimney gases would require an expenditure of about 315 B.t.u. per lb. of wood, which reduces the calorific value to about

$$6187 - 315 = 5872\text{ B.t.u. per lb.}$$

of wood as against 14,000 B.t.u. per lb. of average good coal. There would be somewhat greater proportion of waste of combustible discarded when using coal than wood, reducing the relative boiler evaporative value of coal from 14,000 to about 13,000 B.t.u. per lb., making each pound of coal equal in value to about 2.2 lb. of wood. Under otherwise equally favorable conditions the use of coal in place of wood should result in a saving of about 44 per cent. of the cost of fuel.

Engineers' Study Course

Trigonometry—IX

LAST LESSON'S ANSWERS

36. The angle C is

$$180 - (10 + 46) = 124 \textit{ deg.}$$

From equation 27 and the table (Lesson II) for the value of the sines of the angles A (10 deg.) and B (46 deg.) and $a = 500$.

$$\frac{500}{b} = \frac{0.1736}{0.7193} \qquad b = \frac{500 \times 0.7193}{0.1736} = 2071.72$$

and from the equation $\frac{a}{c} = \frac{sin\ A}{sin\ C}$

$$\frac{500}{c} = \frac{0.1736}{0.8290} \qquad c = \frac{500 \times 0.8290}{0.1736} = 2387.67$$

(The sine of 124 deg. is equal to the sine of 180 — 124 = 56 deg. and is so found from the table.)

37. From the equation $\frac{b}{c} = \frac{sin\ B}{sin\ C}$

$$\frac{137.5}{512.5} = \frac{0.2250}{sin\ C} \qquad sin\ C = \frac{512.5 \times 0.2250}{137.5} = 0.8386$$

The angle C therefore is 57 deg. and hence A is

$$180 - (13 + 57) = 110 \textit{ deg.}$$

From equation 27

$$\frac{a}{137.5} = \frac{0.9397}{0.2250} \qquad a = \frac{137.5 \times 0.9397}{0.2250} = 574.26$$

38. The angle C is

$$180 - (23 + 134) = 23 \textit{ deg.}$$

From the equation $\frac{a}{c} = \frac{sin\ A}{sin\ C}$

$$\frac{a}{23} = \frac{0.3907}{0.3907} \qquad a = 23$$

(It was evident at once that a would equal c since angle C proved to be equal to angle A.)

From the equation $\frac{b}{c} = \frac{sin\ B}{sin\ C}$

$$\frac{b}{23} = \frac{0.7193}{0.3907} \qquad b = \frac{23 \times 0.7193}{0.3907} = 42.34$$

39. Calling the 85-deg. angle A, the 45-deg. angle B and the 100-ft. side c, the distance between the poles will be the side b which it is required to find. The angle C will be

$$180 - (85 + 45) = 50 \textit{ deg.}$$

From the equation $\frac{b}{c} = \frac{sin\ B}{sin\ C}$

$$\frac{b}{100} = \frac{0.7071}{0.7660} \qquad b = \frac{100 \times 0.7071}{0.7660} = 92.31$$

40. Call the angle to be determined A. The known angle is not one within the triangle but is an *exterior angle*, so called, and its supplement (180 — 45 = 135 deg.) is the B angle of the triangle. One known side is the length of the crank, 18 in. and is the side a, while the other is the length of the connecting-rod, 45 in., which is the side b. The angle required then can be found directly from equation 27.

$$\frac{18}{45} = \frac{sin\ A}{0.7071} \qquad sin\ A = \frac{18 \times 0.7071}{45} = 0.2828$$

Therefore, the angle C is $16^3/_7$ deg., or about 16 deg. 26 min.

SOLUTION OF OBLIQUE TRIANGLES CONTINUED

CASE III

Solutions of triangles having two sides and the included angle given require the use of either *The Law of Cosines* or *The Law of Tangents.* The Law of Cosines is stated thus:

The square of any side of a triangle is equal to the sum of the squares of the other two sides, less twice the product of the sides and the cosine of the included angle.

This may be proved by referring to Figs. 8 and 9 in both of which

$$a^2 = h^2 + BD^2$$

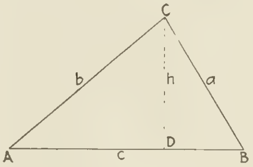


FIG. 8

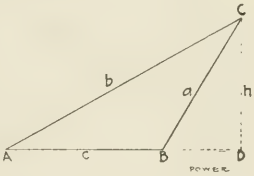


FIG. 9

In Fig. 8, $BD = c - AD$ and in Fig. 9, $BD = AD - c$, so that in both cases

$$BD^2 = AD^2 - 2\,c \times AD + c^2$$

Therefore, in all cases,

$$a^2 = h^2 + AD^2 + c^2 - 2\,c \times AD$$

But,

$$h^2 + AD^2 = b^2$$

and

$$AD = b\ cos\ A$$

Therefore,

$$a^2 = b^2 + c^2 - 2bc\ cos\ A \qquad (28)$$

In the same way it could be shown that

$$b^2 = a^2 + c^2 - 2ac\ cos\ B$$

$$c^2 = a^2 + b^2 - 2ab\ cos\ C$$

The Law of Tangents is stated thus:

The sum of the two sides of a triangle is to their difference as the tangent of half the sum of the opposite angles is to the tangent of half their difference.

This may be proved as follows:

From equation 27

$$\frac{a}{b} = \frac{sin\ A}{sin\ B}$$

Adding 1 to both sides of this equation

$$\frac{a}{b} + 1 = \frac{sin\ A}{sin\ B} + 1 \text{ or } \frac{a + b}{b} = \frac{sin\ A + sin\ B}{sin\ B}$$

Subtracting 1 from both sides of equation 27

$$\frac{a}{b} - 1 = \frac{\sin A}{\sin B} - 1 \text{ or } \frac{a - b}{b} = \frac{\sin A - \sin B}{\sin B}$$

Dividing the first by the second,

$$\frac{\frac{a + b}{b}}{\frac{a - b}{b}} = \frac{\frac{\sin A + \sin B}{\sin B}}{\frac{\sin A - \sin B}{\sin B}}$$

Canceling the b's and the $\sin B$'s,

$$\frac{a + b}{a - b} = \frac{\sin A + \sin B}{\sin A - \sin B} \qquad (29)$$

In the answer to question 18 in Lesson V there was deduced the equation

$$\sin (A + B) + \sin (A - B) = 2 \sin A \cos B$$

Similarly, as there worked out, it could be shown that

$$\sin (A + B) - \sin (A - B) = 2 \cos A \sin B$$

By making $A + B = x$ and $A - B = y$, then A would equal $x - B$ and also $y + B$, so that $2A = x - B + y + B = x + y$ and $A = \frac{1}{2}(x + y)$, and in the same way $B = \frac{1}{2}(x - y)$. Then substituting in the last two equations they would become

$$\sin x + \sin y = 2 \sin \tfrac{1}{2}(x + y) \cos \tfrac{1}{2}(x - y)$$

$$\sin x - \sin y = 2 \cos \tfrac{1}{2}(x + y) \sin \tfrac{1}{2}(x - y)$$

Dividing the last two, one by the other,

$$\frac{\sin x + \sin y}{\sin x - \sin y} = \frac{2 \sin \frac{1}{2}(x + y) \cos \frac{1}{2}(x - y)}{2 \cos \frac{1}{2}(x + y) \sin \frac{1}{2}(x - y)}$$

But as $\frac{\sin}{\cos} = \tan$ and $\frac{\cos}{\sin} = \cot$,

$$\frac{\sin x + \sin y}{\sin x - \sin y} = \tan \tfrac{1}{2}(x + y) \cot \tfrac{1}{2}(x - y)$$

Again, as $\tan = \frac{\cot}{1}$, and substituting A for x and B for y, as the application is general and either represent any angles,

$$\frac{\sin A + \sin B}{\sin A - \sin B} = \frac{\tan \frac{1}{2}(A + B)}{\tan \frac{1}{2}(A - B)}$$

Finally, substituting this value for $\frac{\sin A + \sin B}{\sin A - \sin B}$, in equation 29,

$$\frac{a + b}{a - b} = \frac{\tan \frac{1}{2}(A + B)}{\tan \frac{1}{2}(A - B)} \qquad (30)$$

Given, then, two sides, a and b, and the included angle C of a triangle, the angles A and B may both be found from equation 30, which may be written

$$\tan \tfrac{1}{2}(A - B) = \frac{a - b}{a + b} \times \tan \tfrac{1}{2}(A + B)$$

Since $\frac{1}{2}(A + B) = \frac{1}{2}(180 \text{ deg.} - C)$, the value of $\frac{1}{2}(A + B)$ is known, so that this equation enables determining the value of $\frac{1}{2}(A - B)$. Then A and B can be found, for

$$\tfrac{1}{2}(A + B) + \tfrac{1}{2}(A - B) = \tfrac{1}{2}A + \tfrac{1}{2}B + \tfrac{1}{2}A - \tfrac{1}{2}B = A$$

and

$$\tfrac{1}{2}(A + B) - \tfrac{1}{2}(A - B) = B$$

After A and B are known, the side c can be found by The Law of Sines.

By another method the side c may be found directly from one of the alternative forms of equation 28

$$c = \sqrt{a^2 + b^2 - 2ab \cos C}$$

and then by The Law of Sines the angles A and B can be computed.

STUDY QUESTIONS

11. Given $a = 847$, $b = 579.1$, $C = 36$ deg.; find A, B and c.

12. Given $b = 527.8$, $c = 723.6$, $A = 100$ deg.; find the other three parts.

13. It is 60 ft. from the peak to the eaves of a gable roof and the angle at the peak is 110 deg. What is the overall width of the building?

14. A pipe line is to be put underground in a plant, but on account of walls and other obstructions, its length cannot well be measured in advance. From a point outside of the plant, however, 50 yd. from one end of the required run and 90 yd. from the other end, both ends are visible and the angle between the lines of sight is found to be 37 deg. How long must the pipe line be?

15. The supporting legs of a tank tower are 45 ft. long and 15 ft. apart at the base. The angle which the legs make with a horizontal line between the feet is 84 deg. How far apart are the tops of the legs?

* * *

Indicator for Water-Power Plants

By James M. Purcell

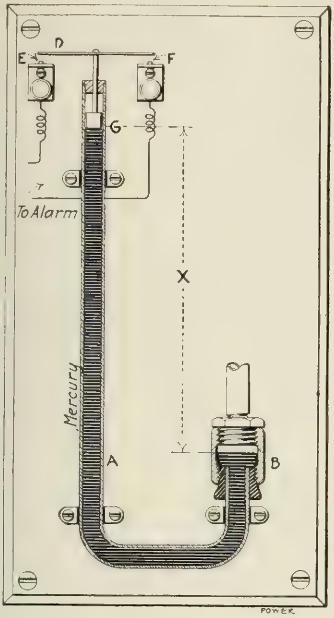
In most low-head water-power plants, racks are generally placed across the wheel-pit openings to catch the logs and trash that may damage the wheels. These racks at times are so obstructed as to interfere seriously with the operation of the plant. An added danger, because of the immense pressures they must bear, is due to the impounded water in front of the racks.

Generally this clogging is caused by two things: In the autumn the leaves are washed from the river banks and are brought down to the racks. This period extends from Oct. 1 into the middle of December. Later on there are ice difficulties. The large cake or surface ice can be easily cared for, but the frazil or "needle" ice causes trouble. This ice appears as needle-like crystals merging into a thick, mushy condition, clinging to the racks even to the bottom, and gradually forming a thickness which presents an impenetrable barrier to the water.

An indicator to show the difference of pressure in the wheel chamber and the headrace may be of interest. This difference between the front and rear of the racks indicates their condition, as foreign matter on the racks would cause a reduction in their area, and a difference of level between the wheel chamber and the headrace. The sketch shows the indicator construction; A is a ½-in. glass tube bent into the form of an ell, on the shorter leg of which a ¾-in. coupling B is attached. Into this coupling a rubber stopper, sufficiently large to make a tight joint, is screwed, a hole is drilled through this stopper and the glass tubing forced in, making a water-tight joint. On the other end of the coupling a bushing reducing to ¼ in. is provided, from which this pipe is run to the bulkhead or any other convenient point.

The distance X is divided, each part being 0.88 in. long, the height of a column of mercury which will balance a foot-column of water. This distance X must be sufficiently long to care for the pressure difference between the race level and the point where the pipe is attached.

An alarm can be provided by putting a light float on top of the mercury column with a rod attached and a contact maker *D* made of a thin strip of copper. If the water in the wheel chamber should be lowered, due to obstructions on the racks, the strip *D* would make contact across the points *E* and *F* and ring the bell. The complete indicator may be mounted on a board. Instead of this rigging a pressure gage might be used. The range of this gage, in pounds pressure, would be the difference in level between *G* and *B* in feet divided by 0.434. The alarm attachment can be fixed by providing a contact brush on the gage hand, which, on reaching a predetermined point on the scale, would complete the circuit through a small copper segment attached at that point.



Indicator to Show Pressure Difference in Wheel-Pit and Head Race

* * *

A Locomotive Crane with an Electro-Magnet Lift, fitted with a small turbo-generator set to furnish electric current for the magnet, has recently been experimented with, by the Brown Hoisting Machinery Co., of Cleveland, Ohio. A 15-ton crane with a 40-ft. boom was fitted with a 5-kw. Terry turbo-generator set. By this means electric wiring, exterior to the locomotive, is eliminated. The turbo-generator set is independent of the other operating portions of the mechanism, which adhere to standard practice, and is mounted in a compartment beneath the floor where stands the operator.

* * *

Humphrey Pumps Tested—Results of the official tests on the Humphrey gas pumps installed at Chingford, Eng., and described in "Power" for Apr. 29, 1913, have just been made public. The pumps were installed under a guarantee of 1.1 lb. of anthracite per water horsepower-hour, but the test showed even better results, the average fuel consumption of the four large pumps being 0.931 lb. and of the small pump 0.8 lb. per water horsepower-hour. The lower fuel consumption of the small pump is accounted for by its greater relative valve area. The average thermal efficiency of the pumps was 23½ per cent. and of the producers 82 per cent.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Eureka! sez he. What? sez I. Perpetual motion! sez he to me. Me eye! sez I to him—an' then we clinched!—"Boiler-room Ballads."

This is a "newly patented primary battery" widely heralded in Chicago as "coming within 5 per cent. of perpetual motion." The enthusiastic salesmen say that "when the invention becomes known coal mines may as well shut down, for heat, light and power will be reduced to one-tenth its present cost." When this "invention" becomes known for what it really is, the fleeing salesmen will need perpetual motion to escape the angry populace.

* * *

Sometimes, even an editor is sent to Bellevue Hospital. One of the "Power" bunch went, not long ago, to write up the power plant of "The largest institute of its kind in the world." The editor was crazy to get it; perhaps, you'll be crazy to read it—the article on page 78. (English is a great language. You can easily say one thing in it and mean another.)

* * *

They say J. P. Morgan has a project for merging London's light and power companies. Let's see, didn't somebody "merge" the New Haven road? The stock was formerly 200; now its 65—sub-merged.

* * *

"One day I noticed the valve gear of one of our 300-hp. Corliss engines making an awful noise, the valves being so dry that the dashpots could hardly pull the valves closed," writes an engineer in Cuba. "I found the lubricator reservoir to be full of ordinary thin bearing oil, which the oiler said he had been ordered to use. I straightened out the trouble by substituting cylinder oil and then asked the chief mechanic how he could make such a mistake. 'Why, I'm saving all the drip oil from the engine and filtering it. I thought that the best place to use it was in the cylinder, as there was no babbitt metal there to melt if it happened to run hot.' "

* * *

The new appearance of the A. S. M. E. "Journal" is bully! It just sticks right out, with its standard size (9x12) and handsome typography. Welcome to our mongst! as our chief would say.

* * *

"Relations between Engineering and Art"—Headline.

This must be what is meant by "strained relations." Some time when you're down town in New York, stand in front of the new Municipal Building and watch a dinky horsecar oozing out between gigantic stone columns and drawn by a couple of horses who also have strained relations, probably—soaps, fats and suchlike. Art may be a relation, but in some engineering its relationship is like the Scotchman's cousin—16 times removed.

* * *

The trade papers are giving much publicity to the flatiron campaign out in Defiance, Ohio. Glad this town can get away with it. A man who once held a flatiron in defiance, when the domestic campaign was hottest, told us it couldn't be done—and the "peak of the load" was the least profitable.

* * *

"Henry J. Scriver, engineer of the Stearns Lumber Co., Neponset, Mass., was thrown 15 yards into the air, turned several somersaults and came down on his feet when a boiler at the plant exploded. Beyond Scriver's slight injuries, the only damage was to the boiler room. When the explosion occurred, the blast all but blew the roof off, and with it the engineer. The shock of landing was so great that it almost knocked his wind out.

"The police made an investigation into the cause of the explosion, which they believe was due to a defective pipe that ran through a pile of sawdust."—"Boston Herald."

Hen Scriver knows his business—or any other engineer who can land on his feet after a 45-ft. flight, accompanied by sundry portions of roof. What gets us is how the police knew that the defective pipe caused all the commotion.

Lubricating Engine Bearings

By R. E. Crockett

SYNOPSIS—Facts regarding the design of bearing oil grooves, showing why the usual ways of making them are not the best and suggestions for improvements.

⁂

Investigation of a number of bearings which gave trouble from heating, showed the fault to be either insufficient oil grooves or lack of provision for the oil to properly feed in between the shaft and the bearing. This trouble is more pronounced in bearings made with three or four parts.

One way of making quarter boxes and bottom bearings is shown by Fig. 1, in which the edges *A* are chamfered, as shown, and the edges *B* left sharp. With the direction of rotation indicated by the arrow, the parts *C* and *D*, if provided with proper oil grooves, will allow oil to feed between the shaft and bearing, but the sharp edge at *B* of the quarter box *E* will act as a scraper and prevent the oil from working in between it and the shaft. This is further influenced by the shape and position of the oil grooves as usually made in quarter boxes, as shown in Fig. 2.

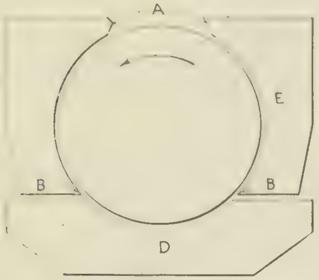


FIG. 1

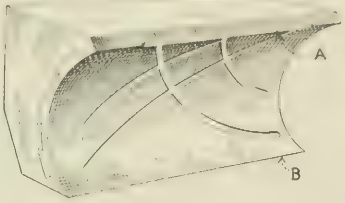


FIG. 2

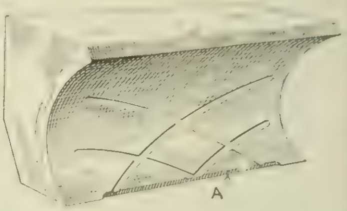


FIG. 3

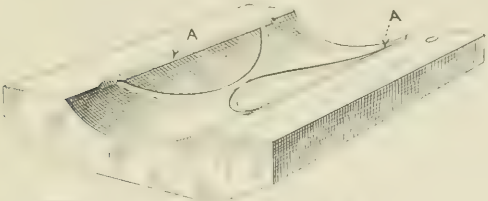


FIG. 4

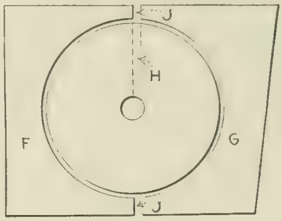


FIG. 5

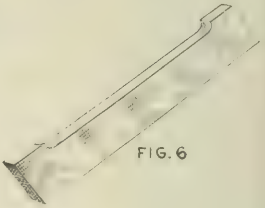


FIG. 6

Showing Details of Bearing Construction, Oil Grooves and Crank-Rod Brasses

On practically all the Corliss engines examined, the front and back quarter boxes are grooved and chamfered alike. The explanation is that this is done so that the engine may rotate in either direction and still feed the oil. As Corliss engines are usually built to order and the direction of rotation is given when ordered, it would seem that the bearings should be made to suit the direction of rotation.

It is evident from Fig. 2 that it is not correct to make the oil grooves alike for both front and back quarter boxes. If the direction of rotation is as indicated by Fig. 1, and the part *E* is grooved as shown in Fig. 3 there will be a chance for all the oil passing under the shaft to be drawn up between the back quarter and the shaft.

Another feature which is often neglected is the oil grooves in the bottom box of the bearing, as it is often made without them. In one case a large air compressor which lacked oil grooves in the bottom box ran hot until deep ones were provided, as shown in Fig. 4. They should be made deep and smooth, to prevent the lodgment of dirt by flooding, when the foreign matter can be washed out.

It is advisable to examine the oil grooves of all bearings occasionally, especially after they have shown a tendency to heat. Sometimes the outside of a large bearing does not indicate heating, while next to the shaft it may be hot enough to drag the babbitt and fill up the oil grooves. After such an occurrence a slight stoppage of the oil supply will cause the bearing to heat up rapidly.

Crankpin boxes of connecting-rods are usually made with oil grooves in both brasses alike, but for the best results they should be made to suit the direction of rotation, but lack of proper oil grooves in the brasses will not cause as much trouble, as on main bearings, when the crankpins are oiled from the center.

Crankpin brasses or boxes *F* and *G*, Fig. 5, are generally left open to allow taking up. As the pin is fed from the center, part of the oil is retained in the oil hole *H* until it passes the openings *JJ*, when it is thrown out and wasted, making more work for the wiper. Fitting a strip of very soft wood into the openings will prevent this trouble. The wood can be compressed considerably before it is hard enough to prevent taking up the wear properly. When putting in wood strips it will be advisable to cut out one side, Fig. 6, so it will not scrape oil off the pin. This point must not be neglected when applying strips under main bearing caps, or a hot bearing may result.

The valve-gear parts of Corliss engines run hot from the high temperature of the cylinder, and when the usual engine oil is used, it is almost immediately thrown off. Cylinder oil is an excellent lubricant for the gear.

The means employed in oiling Corliss valve-gears are not in keeping with the improvements in oiling the other important parts of the engine. The parts are made light and there is no provision for taking up the wear, and the oiling must be done through small holes, often not even countersunk on the outside to assist in getting the oil-can spout into the holes when the valve-gear is in motion. It is easy to put the oil everywhere except where it belongs. Consequently the gear is running without proper lubrication most of the time.

Another thing the writer strongly advocates, is the constant lubrication of piston rods, almost compulsory with metallic packings, and very desirable with fibrous packings. This is best accomplished with an oil cup arranged to feed cylinder oil on top of the rod. The best results are obtained when the rod is kept clean and free from dust and grit by the device shown in Fig. 7. It is made from a piece of spring steel, about $\frac{1}{16}\times\frac{3}{4}$ in., formed as at *K*, and a little larger than the piston rod. It is wound with candle wicking as at *L*, sprung over the rod and fastened to the gland nuts. After once being saturated with oil it will keep the rod clean and well oiled.

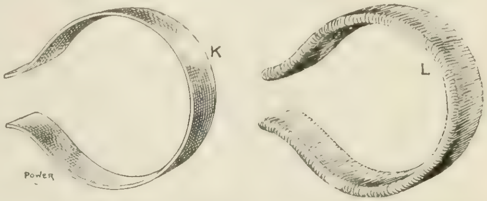


FIG. 7. PISTON-ROD LUBRICATING RING

Most engineers may be well acquainted with the foregoing suggestions, but because they are simple they are often neglected.

⁂

Oil Storage and Piping

By J. J. McIntosh

SYNOPSIS—Storage and conveyance of oil and systems of piping for large and small plants.

⁂

Plants using fuel oil must have ample facilities for storage. This is accomplished by constructing tanks either above or below ground. Where tanks are placed above ground they are usually constructed of steel. Underground tanks are constructed of reinforced concrete and should always be plastered on the inside with a good cement plaster to prevent seepage. All storage tanks should be constructed with properly placed manholes and a vent pipe of ample size. These manholes should be padlocked to prevent a careless person from setting fire to the oil. The vent should always be as straight as possible, and the vent opening should not be placed where there is a possibility of its coming in contact with a naked flame or intense heat. It is advisable to solder fine wire gauze in the vent openings of all oil tanks. This will prevent any back flash into the vent pipe, and at the same time permit easy exit of the vapor.

All fuel-oil storage tanks should be provided with some means to quickly extinguish a fire that might become started from any possible means. This can be accomplished by fitting tanks with a ring of steam pipe, placed at the top of the tank. This ring must be provided with an ample number of openings for jets, and it must be large enough, and be so placed, that it will quickly and effectually provide a solid sheet of steam to cut off the air supply, and thus smother the fire.

The delivery of oil is made in tank cars especially constructed for that purpose, or if on a waterway, from barges or tank steamers. Whenever possible the storage tanks should be so arranged that the supply can be unloaded by gravity directly into the tank, thereby saving pumping costs. The boiler-room supply tank should also be placed as near the boiler room as practical to facilitate pumping. When it is necessary to unload tank cars some distance from storage tanks, a hopper is usually constructed beneath the tracks and connected to storage tanks by means of a pipe line. In the case of receiving oil from barges or tank steamers, it is generally necessary to pump it. In practice it has been found advisable to have the inlet in the storage tanks fitted with a screen to prevent dirt from entering the tanks. This screen must be so arranged that it can easily be removed for cleaning. Storage tanks must also be fitted with a reliable sounding rod or oil gage marked in gallons, barrels or tons per foot.

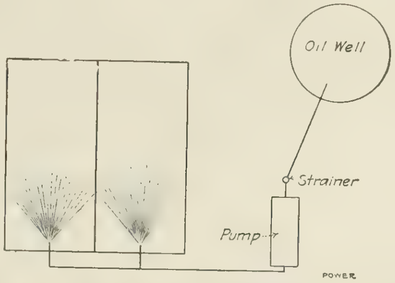


FIG. 1. NONRETURN SYSTEM OF PIPING

The ease with which oil can be stored and conveyed gives it a great advantage as compared with coal. Oil can be unloaded directly from cars into underground storage tanks at a trifling cost. The storage space required for oil is considerably less than that required for coal. Approximately 50 per cent. more heat value can be stored in the same volume of space with oil than with coal. This kind of fuel can be pumped from the storage tank into the furnace as needed. The cost of equipment required is small as compared with the conveying equipment necessary to handle coal. If a plant is located at a considerable distance from the points of unloading, the difference in the cost of handling these two fuels assumes proportions that cannot be overlooked. For example, in a certain case the cost of pumping a 10,000-gal. car of oil 3300 ft. against a 20-ft. head, by electrical power at 10c. per kw.-hr., was $3. The cost of handling this same heat value in coal was $21.

OIL PIPING AND PIPING SYSTEMS

In Fig. 1 is shown an arrangement of oil piping known as the nonreturn system. After leaving the tank, the oil passes through the strainer placed in the suction, and then directly into the pump, thence to the burners. This is about the simplest arrangement of piping that could be devised, and, while it is used to a certain extent in small plants, it is not recommended. The economy of such a system will be far below that of a correctly fitted up installation. The operating engineer who has to contend with a system of this character can improve matters some by installing two oil strainers instead of one. Fig. 2 shows a set of oil strainers so arranged that one strainer may be cut out and cleaned without interrupting the pump operation. The design of an oil strainer used in fuel-oil installations must be such that it can be easily and quickly removed and cleaned.

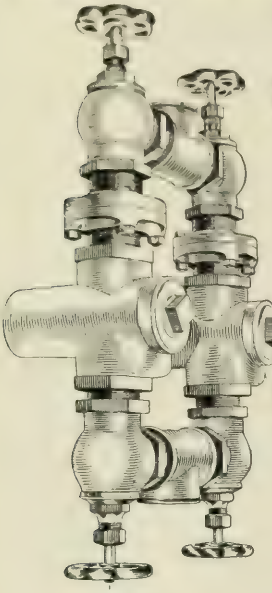


FIG. 2.

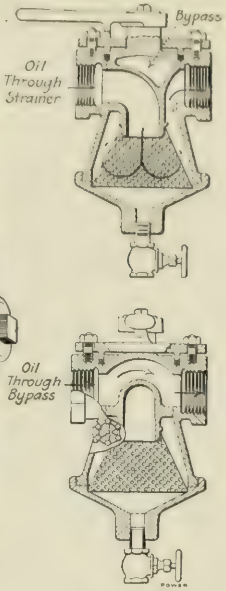


FIG. 3.

Fig. 2. Set of Oil Strainers Arranged So That One May Be Bypassed. Fig. 3. Oil Strainer Well Adapted for Oil-Burning Plants.

Dirt has a persistent habit of working into oil tanks. If the oil tanks are not covered absolutely tight, except for the vent, so that no foreign matter can work itself into the oil, trouble is sure to occur sooner or later. In some plants great annoyance is caused by foreign matter in the oil. In many cases this is not so much the fault of the oil companies delivering the oil as to carelessness at the plant.

Fig. 3 shows a type of oil strainer that is well adapted for oil-burning plants, provided that a strainer is located on both the suction and discharge sides of the pumps. When it becomes necessary to clean this strainer, the oil is forced through the bypass and the strainer is cleaned by steam, the dirt being forced out through the valve at the bottom.

In Fig. 4 is shown a system of oil piping that is known among practical engineers as the circulating system. In this arrangement the suction in the oil tank is surrounded by a heating coil to facilitate pumping. The oil is drawn from the tank through the duplex suction strainers into the pump. After leaving the pump, it flows through the duplex discharge strainers into the oil heater located beneath the pumps and through the gas separator and oil meter into the burner line. The unused portion escapes through the bleeder valve back into the oil well. Some engineers prefer having this return oil led back into the suction near the pumps. This arrangement is often the source of trouble because of gas that has become entrapped in the oil being led back into the suction. This gas causes the pumps to work irregularly, thereby varying the oil pressure. The gas separator is for the purpose of separating any gas that may have accumulated and also smooths out the pulsations of the pump. The gas-overflow valve at the top of the separator must be kept closed, except in times of trouble when gas is being formed, and the separator should be located at the highest point in the system. It will be found advisable to place a thermometer at some convenient point, on both the suction and discharge sides of the pumps, so that the firemen may observe the oil temperature at all times.

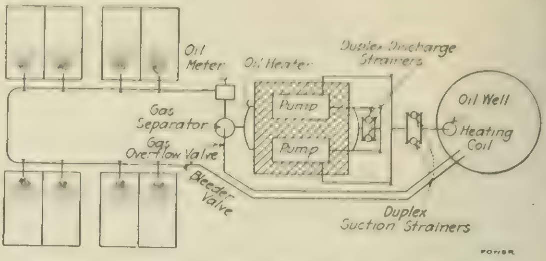


FIG. 4. CIRCULATING SYSTEM OF OIL PIPING

Fig. 5 shows the general arrangement of the Koerting mechanical oil-burning system on a stationary boiler. In the drawing, *B* is the burner, attached to the air register, *SI* is the steam inlet to the oil heaters, *D* the steam discharge from heaters, *H* the oil heaters, *P* the oil-pumping outfit, *PS* the pressure strainer, *SS* the suction strainer, *LS* the steam blowout, *T* a thermometer and *DIC* a duplex interlocking cock.

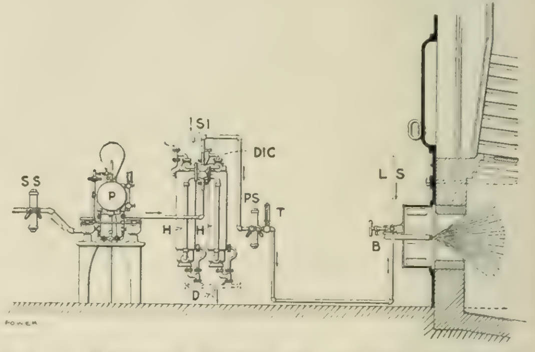


FIG. 5. KOERTING SYSTEM ON STATIONARY BOILER

Fig. 7 shows an oil-burning system that is used to a considerable extent in some of the Western states.

There are several different methods of regulating the fires. It may be done by adjusting the burners under each boiler for a change in load. As the amount of oil forced into the furnace varies, and consequently the fire, with a varying oil pressure, it is obvious that it is of advantage when firing by the above method, to maintain a constant oil pressure. This may be accomplished by placing a governor on the oil pump or, when using a system, as in Fig. 4, by placing a regulating valve in the oil overflow.

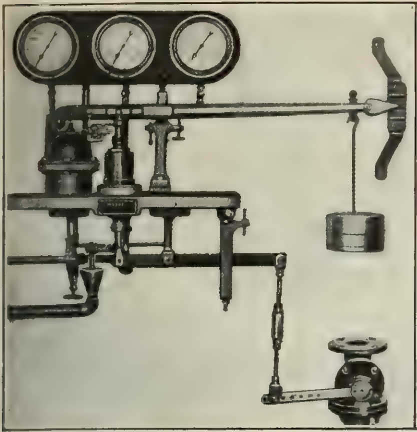


Fig. 6. Oil Regulator in Moore System

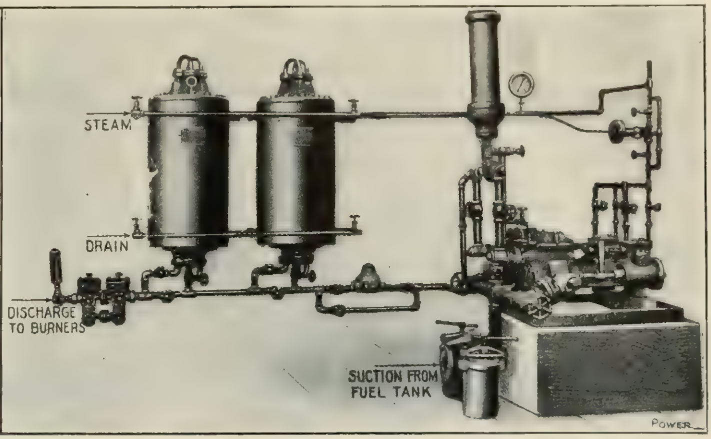


Fig. 7. System Commonly Used in Western States

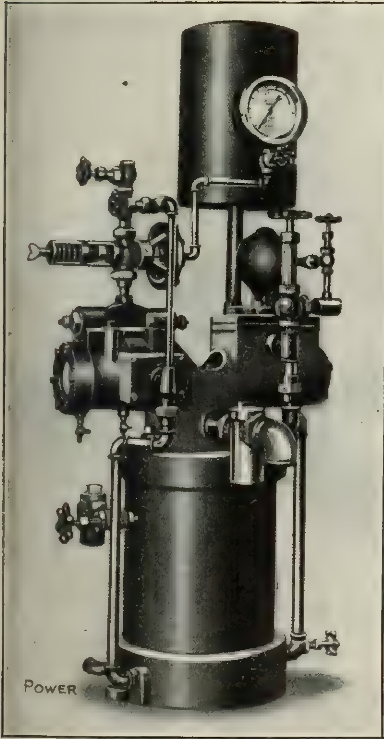


Fig. 8. Small Outfit Suitable for Boilers of 25 to 150 Hp.

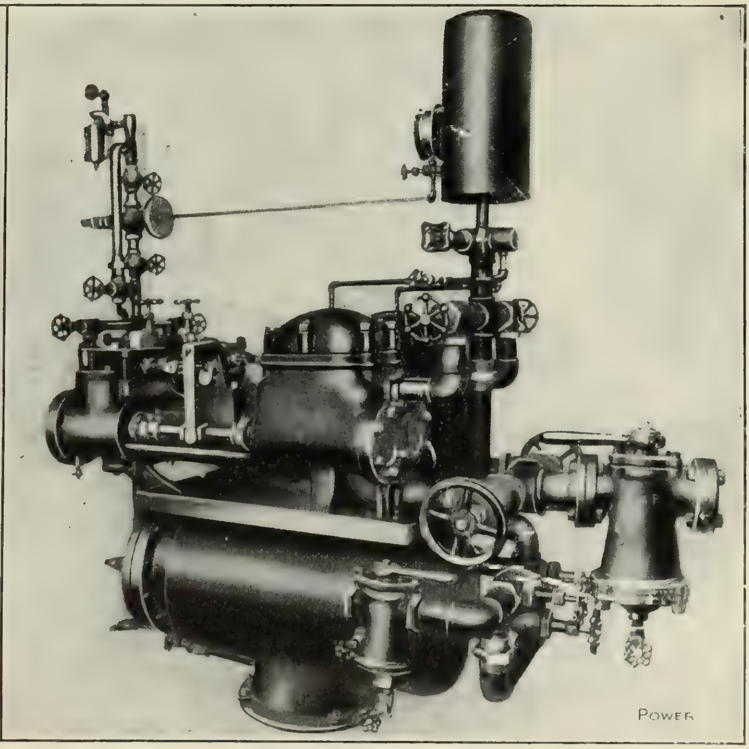


Fig. 9. Outfit for Plants Ranging from 250 to 3000 Hp.

Another method of firing is to open the oil valves on all burners wide open, or nearly so, and regulate the fires under all boilers by means of the bleeder valve. In a plant of any size, carrying a variable load, it would be difficult to maintain a steady steam pressure by the first named method of firing. By using the second method, it is possible to regulate the fires under all boilers according to the demand for steam by one operation from a convenient point in the boiler room. Any sudden changes in load can be immediately compensated for. The load can be divided between all boilers and each unit made to deliver its share under varying load conditions. A higher economy is the direct result.

There are a number of patented automatic systems of firing in use. One of these systems that has come into prominence, probably because it has been installed in one of the largest plants in the West, which has a record for high economy, is the Moore system. It consists of three independent regulators, namely, oil to burner regulator, steam to burner regulator and the damper controller. The regulators control the supply of oil to all burners, the supply of atomizing agent to all burners, and the supply of air for combustion, all from a central point. This system can be arranged to care for any number of boilers. Fig. 6 shows the regulator controlling the oil to the burner

Figs. 8 to 10, inclusive, show a make of apparatus that has gained considerable favor both in stationary work and on shipboard. Fig, 8 illustrates a small outfit suitable for a boiler of from 25 to 150 hp. The outfit shown in Fig. 9 is designed for plants ranging from 250 to 3000 hp. The general arrangement of one of the sets is shown in Fig. 10.

In an oil-burning system it is important that ample provision be made for heating the oil. The hotter the oil the greater the ease of atomization. As fuel oil gives off vapors at a comparatively low temperature, the oil on the suction side of the oil pumps cannot be heated to the desired temperature. It is, therefore, customary to heat the oil in two stages—first on the suction side, usually in the oil tank, and, second, by means of an oil heater on the discharge side. In some installations exhaust steam is used in the heating coil in the oil well and also in the oil heater. In others, exhaust steam is used in the well alone and live steam in the oil heater. To raise the oil to a high temperature, it will generally be found necessary to use live steam in the heater. In oil-burning systems, using steam as an atomizing agent, the oil delivered to the burners ought to be heated to at least 135 deg. F.

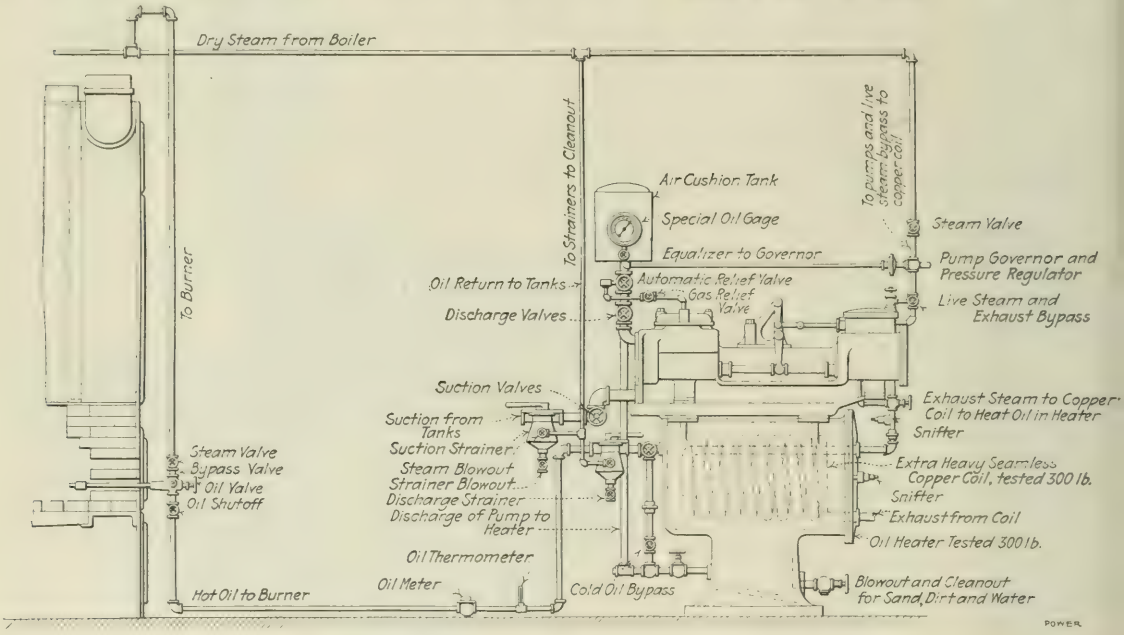


FIG. 10. GENERAL ARRANGEMENT OF SYSTEM FOR POWER PLANT

In mechanical fuel oil burning systems the oil is heated to a temperature of about 260 deg. F. The formation of gas at this temperature is prevented by carrying the oil pressure in accordance with the temperature.

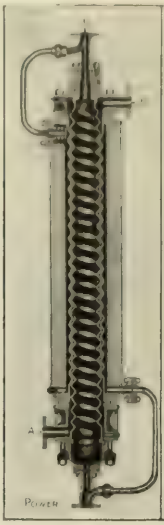


FIG. 11

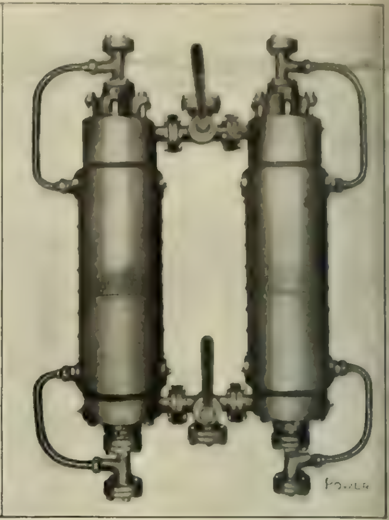


FIG. 12

Fig. 11. Heater for Raising Oil to High Temperature. Fig. 12. Heater of Fig. 11 Arranged in Duplex

In Fig. 11 is shown an oil heater especially constructed for heating the oil to a high temperature. The oil enters at *A* and is discharged at *B*. Steam enters at *C;* part of it is carried by the branch pipe between the shell and outer tube and the other portion enters the inner tube. Fig. 12 shows the same heater arranged in duplex, thereby allowing one heater to be cut out for cleaning or repairs without interfering with the operation of the plant.

In the above type of heater, all joints are external. Experience has shown this to be the best method of construction. In Fig. 13 is shown the usual method of placing a heating coil in an oil well. The pipe used in such a coil should never be smaller than 2 in.

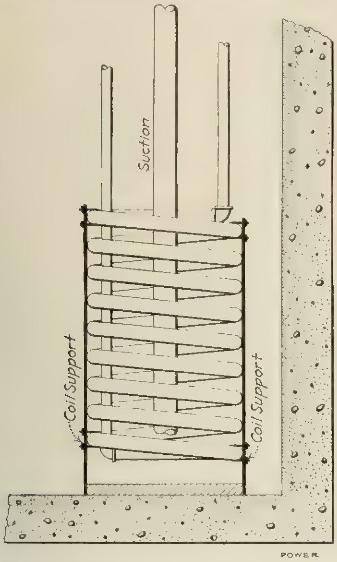


Fig. 13. Usual Method of Placing Heating Coil in Oil Well

Gas Analyses Proved Worth While

By T. E. Griffith

It was the writer's earnest desire to learn why the coal consumption per kilowatt-hour in his plant varied so much from day to day. Believing that this was largely due to firing methods, a list of apparatus required for flue-gas study, giving the expense and advantages to be gained, was made out and presented to the office. It was turned down flat, but through the assistance of a drummer, who frequented the engine room, the loan of an Orsat apparatus, acids and all, was obtained. Then, all that remained to be done was to change the piping and charge it to "boiler repairs."

Each boiler intake was tapped for a ¼-in. gas pipe that reached to the center of the uptake just above the water tubes. These pipes were connected to a ¼-in. header extending along the end of the boilers. From this a line was run to a testing shelf in the engine room, and all was ready for a series of tests on each boiler. The gases were carried through a sight bottle and on to a tap in the condenser intake, where a valve could be cracked so as to allow the desired amount of gas to pass; this being so small as not to affect the condenser. The sight bottle showed just how much gas was passing and any stoppage of flow, which was frequent, in the line.

Our plan was to get the actual furnace conditions hour by hour, during twenty-four hours. This would indicate the hours during which the best results were obtained. The coal was weighed each hour, and, at the same time, kilowatt readings at the switchboard were taken, and also as many flue-gas tests as possible. Curves were plotted showing the total number of pounds of coal burned per hour, the kilowatt load, the horsepower of the boilers connected and the pounds of coal per square foot of grate area.

Before obtaining a sample, the gases were caused to flow through the sight bottle *S*, Fig. 1. The flow was regulated by valve *F*, valve *T* being used only to test the sight-bottle connections for leaks. Valve *K* was used to prevent air from backing up into the pipe when a change of gas receivers was being made.

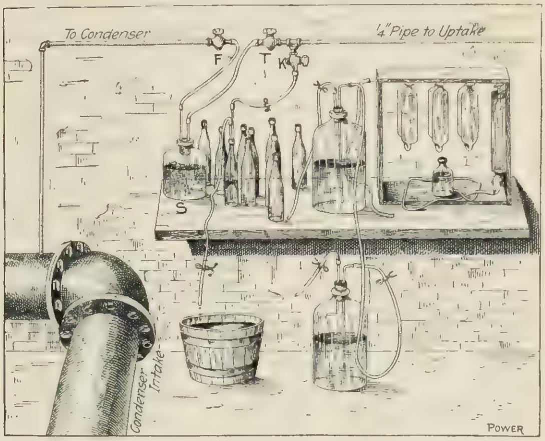


Fig. 1. Testing Shelf in Engine Room

When a test of the gas at some precise moment was desired and there was plenty of time to work out the test before taking another, the sample was introduced directly into the apparatus. But to get a series of samples taken in rapid succession over a period of time, say four or ten minutes, the time of one firing to another, a set of one-quart beer bottles, each fitted with a two-hole rubber stopper, were obtained. Two glass tubes, one extending to the bottom of the bottle and the other not quite through the cork, were also provided for each bottle. If the short tube extended more than through the cork, it was impossible to get all the air out when filling the bottle with water ready for a sample. Connections were made with rubber tubing and pinch-cocks served as valves.

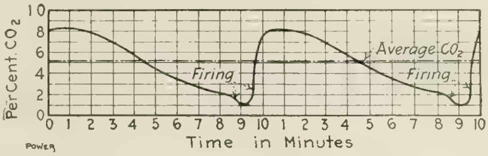


Fig. 2. Percentage CO_2, 10-Min. Fires, 7 to 9 Shovels to Door, 3-In. Ash on Grate

To get an average sample of gas covering any period of time, two 3-gal. demijohns, such as are shown in Fig 1, were used, the pinch-cock on the discharge being set so that the demijohn would be emptied of water and filled with gas in the desired time.

Fig. 2 was plotted to show just how a 10-min. fire acts. This was the kind of firing used during the light loads. The fireman threw seven to nine full shovels in each door. This, of course, is not the best method of firing; but, nevertheless, it was the method our men used most of the time. The fire at first produces smoke, the CO_2 goes to 8 per cent. with a trace of CO. The CO_2 increases to 8.4 per cent., then drops to 7.8 per cent. and on down, as the fire burns, until the door is opened for a new fire. It then drops to 1 per cent., but quickly rises to 8 per cent., as the firing is completed. It is interesting to notice the shape of the curve for the first four minutes of the period and to consider the advantage had the boilers been fired again at that time and the low last half of the curve avoided.

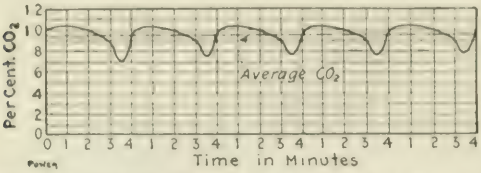


FIG. 3. PERCENTAGE CO_2, 4-MIN. FIRES, 4 SHOVELS TO DOOR, 3-IN. ASH ON GRATE

Fig. 3, taken when the load was heavier, shows a 4-min. fire. Here the average and the high part of the curve are considerably greater than in Fig. 2, and the coal burned per kilowatt-hour was lower.

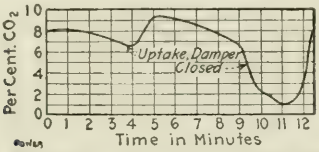


FIG. 4. EFFECT OF DAMPER ON PER CENT. CO_2

Fig. 4 was taken during average load conditions, when the boiler "popped off" viciously and the damper was closed. The CO_2 ran much higher than usual, and this suggested that it might be just as well to use the damper more or less to regulate the supply of air. All these readings were taken with the fires fairly clean.

Fig. 5 was taken when the fires were dirty, with from 6 to 9 in. of ash on the grates. The load was fairly light and it is surprising to see the high position of the CO_2 curve. During this period the coal consumption was also light. Apparently the thick bed of ashes tended to retard the flow of air and fill the same office as a stack damper.

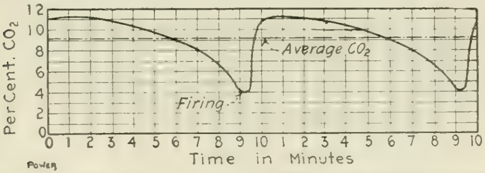


FIG. 5. PERCENTAGE CO_2, 10-MIN. FIRES, 7 SHOVELS TO DOOR, 6- TO 9-IN. ASH ON GRATE

These tests were of great value. We saw that ridiculously poor methods of firing had been used and we were able to show the firemen just where and how it all happened. The results from the gas apparatus were verified to their absolute satisfaction by the records of coal burned per kilowatt-hour during the same interval of time. Dampers with chain controls within convenient reach of the firemen were at once installed, the fires were carried thicker and more even and it is needless to say that the coal per kilowatt-hour dropped an appreciable amount.

This shows the results that an ingenious and thinking engineer may obtain even though the men higher up are, seemingly, limiting and preventing him from showing his real worth. The test cost us less than $5. The education of the firemen was worth much more, not to mention the saving in fuel.

*

Rate Discrimination by a Municipal Plant

On Nov. 16, 1913, a petition was filed in the Court of Common Pleas, Franklin County, Ohio, in which the city of Columbus was the plaintiff and the defendants named were certain city officials, namely, the mayor, director of public safety, director of public service, superintendent of the municipal electric-light plant, the auditor of the city, and the Kilburne & Jacobs Manufacturing Co., a corporation in the city, which under contract was obtaining electricity from the municipal lighting plant.

This suit was brought by Stuart R. Bolin, the city solicitor, in compliance with the written request of James M. Butler.

As the officials of the city were without the services of the city solicitor to defend them, it became necessary for the council to act, which they did by engaging the services of the firm of Weinland & Scarlett, of Columbus.

On Mar. 8, 1913, the city solicitor apparently yielding to the pressure of public opinion, appeared before the court and moved for leave to dismiss the action without prejudice to future action. The court ordered the action dismissed.

Then as the city solicitor, Bolin, refused to bring action as requested, James M. Butler, as a private individual, through Max Goldsmith and James M. Butler, attorneys, on Mar. 14, 1913, instituted proceedings by filing a petition in the court of common pleas, naming James M. Butler as plaintiff and the parties named in the previous petition as defendants, except the Kilburne & Jacobs Manufacturing Co.

The contract with the Kilburne & Jacobs Manufacturing Co. calls for electricity not in excess of 500 kw.-hr. for a period of five years. The consumer is to pay the city a net rate of $0.0155 per kw.-hr., and in consideration of the low rate, the consumer agrees to use not less than 300 kw. per hr. during the hours from 6:30 a.m. to 6:30 p.m. on working days, and also agrees not to use current between the hours of 6:30 p.m. and 6 a.m. when requested not to do so by the city, excepting for the operation of such machinery and lighting as may be essential for the preservation of life and property." If the consumer desires to do lighting during the day, the city will furnish the current at the same rate as power.

The petition of Mr. Butler claimed that the city through its officials is maintaining and operating a plant to furnish current to illuminate the city, to sell power to the city and to sell to private consumers. That many streets and public places are not now lighted, because the plant has not capacity to extend its system. That the prices to private consumers are substantially less than the costs of generating, distributing the current and paying interest on the bonds. That prices charged to the consumers are not uniform. That although much of the current sold to private consumers is for daytime consumption, during many months of the year, the street lights are lighted often earlier than 4:30 p.m., whereas nearly all the private consumers use current until at least 5:30 p.m., and frequently later. That by reason of sale of current to private consumers at less than the cost of generating and distribution, including proper interest and depreciation charges, the city, plaintiff and all other taxpayers are directly paying a part of the cost of current for private consumers. That, therefore, public funds of the city are misappropriated. That by reason of the overlapping of time in private and public use of the current, the plant is unable to carry a larger load and light the public places now needing light. That the city officials, etc., are exceeding their authority and that of the city. That, therefore, the tax rate and taxes are higher. That public requirements are neglected and denied for the benefit of the private consumers. That the machinery and equipment of the plants are overloaded and burdened far beyond the factor of safety, thus imperiling the public system of the city. That the plant is rapidly deteriorating and depreciating and greatly in excess of the standard and necessities of a properly loaded plant. That there is no adequate remedy in law for the city, citizens and taxpayers save in a court of equity.

The action sought to enjoin the city and its officials from entering into any further contracts with any person for the use of current for private purposes at any rate or price, which will not return to the city a fair profit over and above the cost of production and distribution, including proper interest and depreciation charges. It also requested that the present private contracts for the sale of electrical energy at less than cost be terminated and held as naught. That the city be enjoined from entering into any contract for the sale of current for private purposes until such time as it will not prevent the city from extending the public lighting system, and especially from furnishing current for private use at any time or hour when the street-lighting system is in operation; and that in selling current for private use the officials be enjoined from discriminating either as to price or as to location.

On Apr. 7, 1913, a demurrer was filed by the city solicitor's office, defending the city on the following points:

(1) The plaintiff has not legal capacity to bring action.

(2) The court has no jurisdiction.

(3) The petition does not state facts which show a cause of action in favor of the plaintiff and against any or all defendants.

The court overruled No. 1 and No. 2, the defendants excepting to the ruling, but sustained No. 3, the plaintiff excepting.

In rendering the decision the court considered the petition of the plaintiff under the following headings:

1. Prices charged—less than cost.
2. Prices charged not uniform.
3. Overlapping of time of city and private service and overloading machinery by private loads.

It would appear from the complaint, said the court, that the plaintiff entertains the view that the city has no right to sell current to private consumers, except at a price which will at least equal the cost of generating and distributing it to the consumers and the interest charged upon the bonds. The court does not understand how this can be a correct measure by which to determine a proper rate for current. This leads to a consideration of the objects and purposes to be accomplished by the city in the construction and maintenance of this plant. The statute, Section 3618, provides that "the municipalities shall have the power to establish, maintain and operate municipal light, power and heating plants and to furnish the municipality and the inhabitants thereof with light, heat and power to procure everything necessary therefor and to acquire by purchase, lease, or otherwise, the necessary lands for such purposes within and without the municipality." Section 3928-12 provides that, "the city council when it deems necessary, may issue and sell bonds for erecting or purchasing gas works, or works for the generation and transmission of electricity for the supply of gas and electricity to corporations and the inhabitants thereof."

In the light of these provisions the court held that there could be no doubt as to the right of the municipal corporation to manufacture and sell electricity for light, power or heat to private consumers from its municipal plant. The mode of the exercise of this power is confided to the discretion of the city officials. They are not required by the statute to light all the streets and public places of the city before furnishing current to private consumers. It is doubtful if a city is under obligation to light its streets at night in the absence of statutory requirement, although there is apparently some conflict in the decisions on this subject. It may be more economical for the city to furnish current to light a part of its streets from the municipal plant in conjunction with furnishing power and light to private consumers and to light a portion of its streets by private contract, and that discretion cannot be controlled by the court. If the city assumes the exercise of this power and undertakes to furnish current to private consumers, it must do so in competition with other corporations. The position of the plaintiff in reference to this question of the price of current to private consumers is that the contracts with private consumers must be at a sufficient rate to provide for generating and distributing the current and also to provide for the payment of the interest on the bonds. Upon what principle can the entire interest charge on the bonded debt created for the purpose of building, equipping and enlarging the plant be charged upon the current furnished to private consumers? The interest on the bonds issued for that purpose is a fixed charge, which must be met either by the earnings of the plant, or by taxation. If the plant is confined in its operations wholly to the lighting of the streets and public places of the city, the entire charge must be met by taxation. If, however, current is sold to private consumers at a rate which will cover the cost of generation and distribution and some portion of the interest charge, to that extent the taxpayers are relieved of the burden. What proportion of the current generated at the municipal lighting plant is furnished to private consumers and what proportion is used in lighting the streets and public places is not disclosed. If the amount furnished to private consumers is but a small part of the total current generated, and if that same portion of this current should be charged with the burden of the interest charge on the bonds issued for building, equipping and enlarging the plant, it would seem clear that the municipal plant would stand but little chance in competition with a privately owned plant which distributed that charge notably to the entire output of its plant. The complaint, therefore, with reference to the price charged to private consumers furnishes no ground for interference by the court, or rather, it should be said that the petition does not state facts to show that there is any just ground for complaint as to the price.

The next complaint is that the prices charged to private consumers are not uniform. The word uniform in its ordinary significance means not varying, unchangeable. The charge is not made more specific. The plaintiff urges that the city officials in charge of the plant have no right to discriminate between those who apply for the use of the current. But what does discrimination mean? The law does not permit corporations, public or private, to discriminate unjustly as to rates. But the law does not and never did require that the rates should be unvarying. The rule is that they must not discriminate in rates to different patrons, so as to give one an undue advantage over another. It is, however, not an undue preference to make one patron a less rate than another, where differences in conditions exist, when there is such a difference in the expense or difficulty of rendering the service as to justify the difference in rates. It would seem that in the case of electric-light companies there are potent reasons which would justify a greater difference in rates than in the case of either railroad or telegraph companies. In the case of a large consumer whose plant is close to the lines of the company, it would seem that power could be furnished at a less rate than to one whose plant is remote, and who uses but a small amount. The petition, therefore, only averring that the prices are not uniform, does not state a fact which shows any right of action for the plaintiff.

The next ground of complaint is that, because of overlapping of the time when current is used by private consumers and the time when it is needed to light the streets and public places of the city and the limited capacity of the plant, many of the streets and public places are not lighted. A city is not required to light all the streets and public places from the municipal plant. It may, if it sees fit to do so, light a part of the streets and public places by contract. It may never have been the intention of the city authorities to light all of its streets and public places from this plant, as it may be that the city is not financially in a condition to so extend its plant that it can at this time do so, but conceding as we must for the purpose of the demurrer, that the city refused, because of the rate of this current to private consumers, to extend at this time the system of street lights from the municipal plant, the court finds no law which requires the city to discontinue its sale of current to private consumers in order to extend the street lighting from this plant. It is doubtless true that one of the purposes for which the plant was erected was to furnish light for the streets, but the city is also empowered in its discretion to furnish current to private consumers. It may be that one of the purposes or objects of the city in erecting and maintaining the plant is to furnish competition in the business of furnishing light and power to the inhabitants of the city. The court sees no reason to hold that one object may not have been as prominent as the other in leading to the erection and maintenance of the plant. In the opinion of the court this furnishes no ground for the interposition of a court of equity.

The next complaint is that by reason of the sale of current to private consumers, the machinery and equipment are greatly overloaded and burdened beyond the factor of safety and are rapidly deteriorating and depreciating in excess of the standard and necessity of a properly loaded plant. To this it may be said that it might just as truly be charged that because of the extent of the lighting of the streets the plant is overloaded and burdened beyond its capacity. But looking beyond that, it is doubtful whether a court of equity will interfere to restrain municipal authorities who are increasing administrative functions upon the mere ground that they are not acting wisely in the judgment of the court so long as their acts are closely within the power granted. It is a well established principle of law that municipal officers, in the exercise of administrative or legislative discretion, are not subject to judicial control or review in the absence of fraud, and there is no charge of fraud made in the petition. A case might be made which would show such gross mismanagement that it would amount to fraud or constitute gross abuse, but it would seem that the averments of the petition on this point are not sufficient to call for the interposition of a court of equity.

The one further complaint is that the prices of current to private consumers have been maintained for two years and will continue to be maintained unless restrained by the court. If the conclusion reached that the petition does not state facts to show that the prices charged are not sufficient to show any abuse of discretion on the part of city officials, the continuance of the rates would furnish no grounds for interference. The conclusion, therefore, is that the petition does not state facts sufficient to show a right of action in the plaintiff and the demurrer is sustained."

The plaintiff was given leave to amend his petition, and, accordingly, an amendment to the petition was filed, in which the plaintiff reiterated the statements and charges and further averred that prices charged by the city for current sold to numerous private consumers were substantially less than not only either the proportionate, fair, just, reasonable equitable or actual cost of generating such current and distributing the same, but also either the proportionate, fair, just, reasonable, equitable or actual part of the interest on the bonds previously issued and the money used for the purpose of building, equipping and enlarging the plant. That the prices charged by the city for electricity to private consumers are far below any just equitable price and far below the cost of production or distribution, even considering all the circumstances under which the said plant furnishes both street and municipal and private light and power and without regard to any profits, and considering also any alleged advantage that may accrue to the said city, because of its sale of current to private consumers. That electricity sold as aforesaid has never at any time been sold at any profit to the city. That on the contrary, the sale has at all times entailed a loss to the city. That the prices charged to private consumers have been at no time uniform under like, similar or same conditions. That consumers under like conditions have at all times been charged widely varying prices without any reason or excuse therefor. That some consumers have been charged higher prices and rates than others, some of whom were under the same, others under like and others under similar conditions, circumstances and situations. That the city has never used, and is now using no uniform, equitable or scientific schedule, or any system of rates whatsoever either for light or power for private purposes. That rates are made without any regard to conditions under which consumers may take electrical energy, and without any regard to any distribution of cost either of generation or of transmission, or of overhead or other cost, as between electricity for the street and public or municipal lighting and power, and that for private lighting and power. That the city through its officers and agents is still arbitrarily furnishing electricity to some customers and refusing to supply other persons living in the same locality under substantially the same conditions and circumstances.

The plaintiff in this later petition seeks to have the court order the defendants to prepare and submit an equitable schedule of rates that will be substantially uniform under like conditions and circumstances, that will not discriminate between citizens and consumers under substantially the same conditions and that will require the consumer to pay at least the substantial cost of the production and transmission.

The matter is now resting at this stage.

It is stated that, after the municipal light plant entered the field of serving private consumers, the Railway & Light Co. reduced its rates.

The yearly return to the city for this private service in 1912 was about $40,000 gross. The total operating expenses were about $84,000. The total interest on the bonds was about $34,400. There were $860,500 bonds outstanding January, 1913. One plant and equipment complete were valued on the books at about $913,000 at that time.

Midwinter Meeting of Stevens Alumni

The midwinter meeting of Stevens Alumni Association was held on Jan. 9 and 10. On the afternoon of the 9th, preceding the meeting, a conference of Stevens graduates and many other consulting and constructing engineers was held in the main assembly hall of the Stevens Institute of Technology, Hoboken, N. J. The principal subject under discussion was "The Engineer's Part in the Regulation of Public Utilities."

Most of the speakers had experienced relations with public-utilities commissions and were unanimous in expressing the opinion that the work of the commissions was seriously handicapped from lack of engineering intelligence on the part of the personnel of the commissions as, up to the present, they have had to depend for technical information mainly on such as has been furnished by the very corporations which the commissions were presumed to regulate.

Several of the speakers referred to instances where commissioners who had been adversely criticized for their rulings both for and against the corporations had taken refuge in their own ignorance of engineering questions, self-satisfied in emulating the sophistry of social economists "who educate themselves by reading each others books" instead of studying physical facts.

President Alexander C. Humphreys thought that as at present constituted the tendency of public utilities commissions is to discourage and break down competition by encouraging monopolies. Speaking of the usual personnel of commissions he said: "I maintain that the facts show that some of these commissions are quite as much in need of regulation as are the public utilities. In a country like ours we cannot blind our eyes to the facts as to how appointments to any such offices too often are obtained. They are part of the spoils of party victory and control. Too often the men appointed are not qualified to exercise the great power placed in their hands.

"I hold that on every one of these commissions the engineering profession should be adequately represented in the persons of men educated in the science of engineering and later trained in the hard school of experience. These men should be voting commissioners. I by no means maintain that because a man is an engineer he is thus necessarily qualified for membership on such a board, any more than he is qualified to be a judge because he happens to be a lawyer. Whatever his profession be, a commissioner should be broadly trained and should have had experience in the exercise of administrative functions."

Addresses were also made by John W. Lieb, Jr., vice-president of the Edison Co., New York; Newcomb Carleton, vice-president of the Western Union Telegraph Co.; James E. Sague, of the Public Service Commission of the second district of New York, and other alumni and invited guests.

In the evening the regular annual midwinter session of the Alumni Association was held at Castle Stevens. On the following morning, Jan. 10, members of Stevens clubs from all parts of the world held a conference, and in the evening the midwinter meeting was closed by a dinner of the alumni at the Hotel Astor, New York. Covers were laid for 400.

American Standard of Fittings and Valves

At a meeting of the Committee of Manufacturers on Standardization of Fittings and Valves, held at 30 Church St., New York City, on Dec. 17, 1913, the following resolution was adopted:

Resolved—That the schedule which was adopted by this committee on Sept. 17, 1913, and which was reported by the committee of the American Society of Mechanical Engineers on standardization of flanges, at its annual meeting held Dec. 3, 1913 (which subject is held over for its next regular meeting), be concurred in and reaffirmed to take effect as originally planned, on Jan. 1, 1914.

SOCIETY NOTES

On Saturday evening, Jan. 10, the second annual banquet of Atlantic City, N. J., No. 9, N. A. S. E., occurred in the large dining room of the Islesworth Hotel, and was well attended. The toastmaster was John Callahan, past state president. The committee of arrangements were George Hasson, Harry Pennypacker, Arthur Truman, John Higgins, Patrick Sheeran, Robert Black, Frank Atkinson, John Haldeman, John Halhersal. Gott. Seeh. William Simms. Among the speakers were National President James R. Coe, Past President William J. Reynolds, National Conductor, John J. Reddy. The mayor of Atlantic City made the address of welcome.

OBITUARY

George O. Harris, of Evansville, Ind., died at his home in that city on Dec. 21 after a long illness. Mr. Harris was an active member of Evansville No. 7, N. A. S. E., having held offices in that association as well as the state and national associations.

POWER

Vol. 39 NEW YORK, JANUARY 27, 1914 No. 4

Initiative

WHICH I WISH TO REMARK
AND THE SAME IS QUITE PLAIN
IF WE GET UP TO DATE,
OUR SERVICE WILL GAIN.
GREAT SUCCESS!
"INITIATIVE."
WORDS AND MUSIC BY N. G. NEER
POWER
L. MORTIMER

THIS is not a new subject, but it is so important to the engineer as to warrant its reiteration.

It is initiative which makes the individual's head stick out above the general mass, where it may be struck by the lightning of advancement.

What profession presents a better field for original thought and action—for *initiative*—than the operating engineer's? Yet, perhaps in few fields is there a greater lack of originality in thought and action.

A prominent railroad official has stated that during a term of years extending over a quarter of a century the operating department of his road showed no record of any suggestion by any engineer, brakeman or conductor for improvement of the company's train service. Every suggestion of this character had come from patrons of the road, and from the higher officials.

The employer of an engineer will never know that he can sing, unless the engineer occasionally tries out his voice in the employer's presence.

[*By Harry B. Goodwin, Holyoke, Mass.*]

Tallulah Falls Hydro-Electric Development

By Warren O. Rogers

SYNOPSIS—This plant, 89 miles from Atlanta, Ga., is operated with a 600 ft. head, the highest in the South. The five turbines are the highest powered in the United States, having developed 18,600 hp. under test. The generators are of 8000 kw. capacity, 80 per cent. power factor. Water, impounded by a concrete dam 700 ft. long and 110 ft. high, provides a supply basin, from which the water flows through a 6670-ft. tunnel to a surge basin from which five 5-ft. steel penstocks lead to the turbine wheels. Electrical energy is generated at 6600 volts and sent out on the line at 110,000 volts to the open-air transformer station, at Atlanta, the largest of its kind in the world.

⁂

It has been predicted that within the next decade Atlanta, Ga., will be a smokeless city; a possibility, because of the abundant water power available within a radius of 100 miles, which warrants a waterwheel installation of

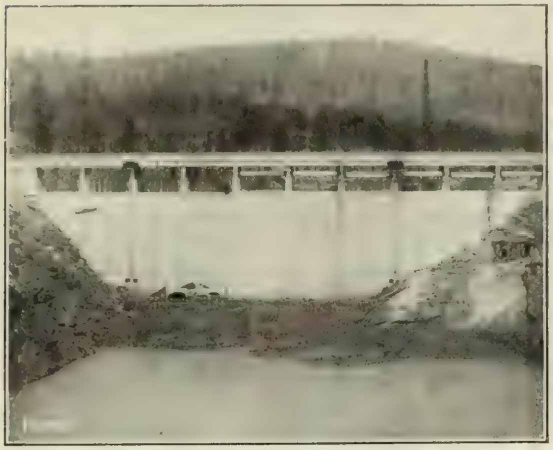


Fig. 1. Upstream View of Dam and Counterweight Flashboards

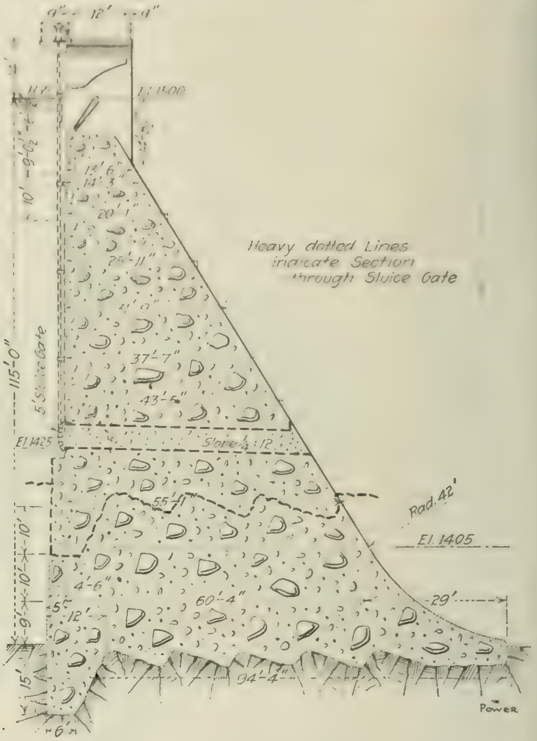


Fig. 2. Section through Concrete Intake Dam at Tallulah Falls

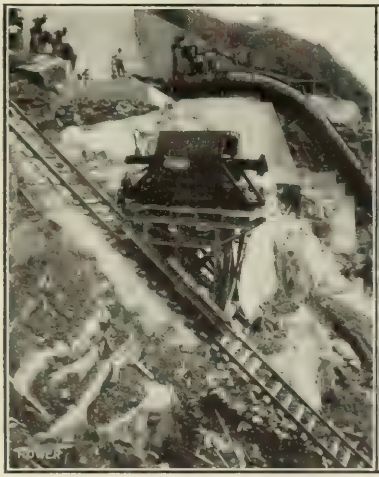


Fig. 3. Remote-Controlled Valves at Head of Penstocks

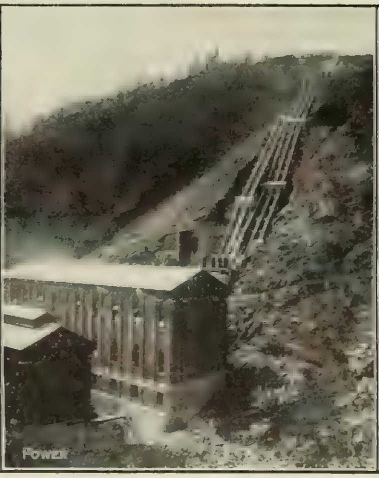


Fig. 4. Penstocks and Concrete Anchorage Blocks

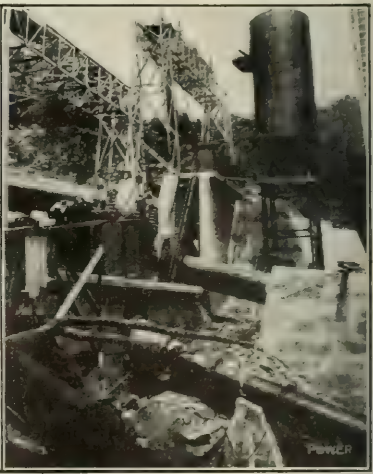
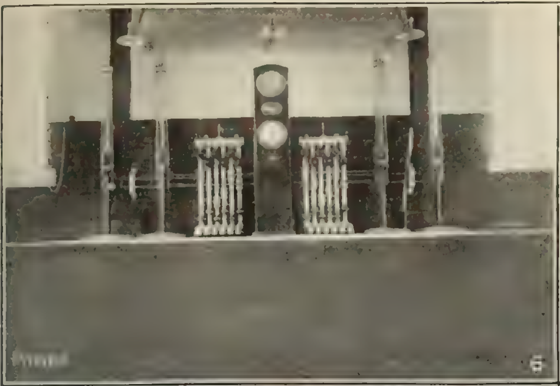
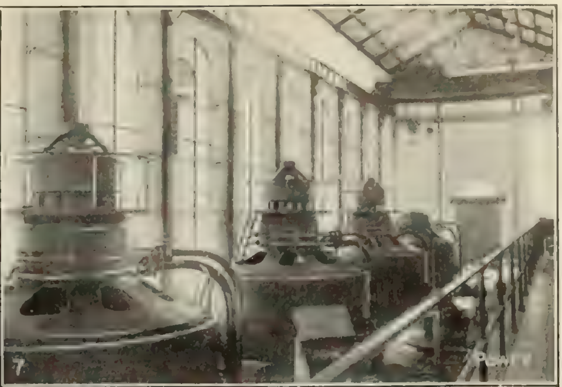
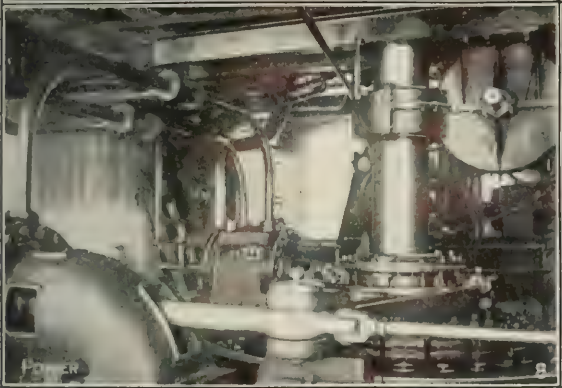
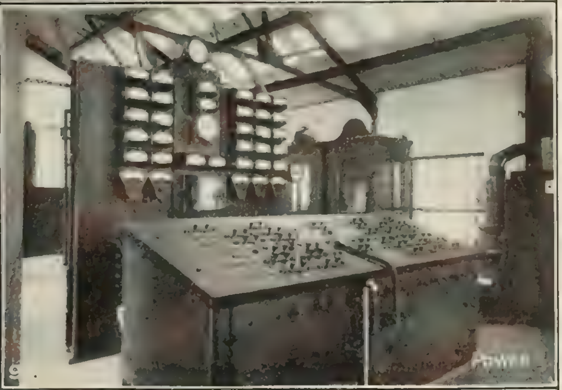


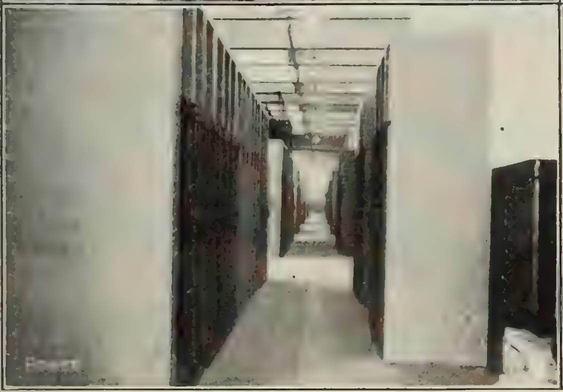
Fig. 5. Venturi Meters and Steel Bridge Towers











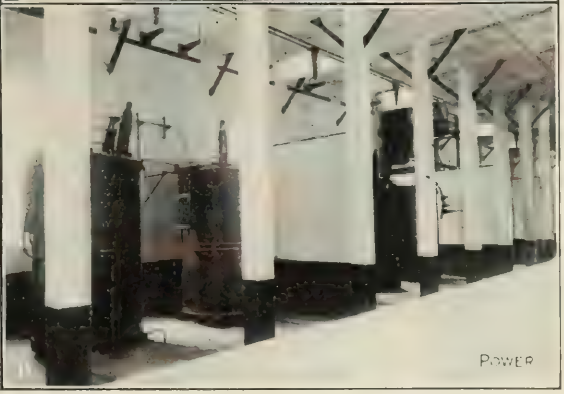


FIG. 6. VENTURI INDICATING AND RECORDING INSTRUMENTS. FIG. 7. PARTIAL VIEW OF THE GENERATOR ROOM AND FOUR 8000-KW. GENERATORS. FIG. 8. HYDRAULICALLY OPERATED WATERWHEEL GATE. FIG. 9. BENCHBOARD IN SWITCH-CONTROL ROOM. FIG. 10. LOW-TENSION BUSBAR AND OIL-SWITCH ROOM. FIG. 11. TRANSFORMERS OF 3333 KV.-A. CAPACITY EACH

approximately 1,600,000 hp. If all of the available developments within 190 miles of the city are taken into consideration, there will be a total waterwheel installation of approximately 3,170,000 hp.

Of the numerous water-power sites, the Georgia Railway & Power Co. owns 10, with a total waterwheel capacity of 345,000 hp. Of these, five are on the Savannah watersheds, four are on the Chattahoochie, and one is on the Etowah watershed. The power plant on the Savannah watershed, nearly completed and partly operated, is at Tallulah Falls, Ga., 89 miles distant in an air line from Atlanta, Ga.

Dams and Storage Water

Storage water for this development is obtained by holding back the water coming from various sources by a storage dam at Mathis, about seven miles above the generator station, where a reserve storage of approximately 1,250,000,000 cu.ft. of water is held to be released for power purposes as the stage of water demands. This dam is of the Ambussen-deck type, 700 ft. long and 90 ft. high; and is provided with three 48-in. hydraulic gate valves to drain the reservoir of water.

The dam has been designed to house a small power plant of two 3000-kw. units which will utilize the energy of the water released from the storage reservoir. This energy will be transmitted to the main power plant and from there sent over the main transmission lines for commercial use.

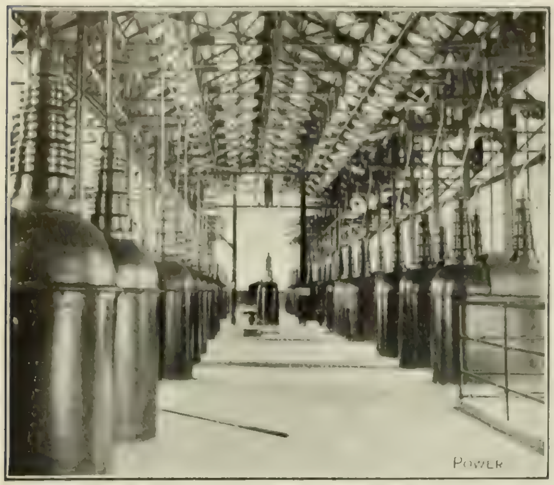


Fig. 12. High-Tension Switch and Busbar Room

About one mile above the power plant is a second or main rubble concrete dam 110 ft. high and arched to a radius of 900 ft.; it is 444 ft. long on the crest. The spillway is 280 ft. long and is divided into 10 sections, as shown in Fig. 1. Each section is fitted with a swinging flashboard, hinged at the lower edge and controlled by a rolling counterweight so arranged that the water back of the dam will be maintained at within 3 in. of the normal elevation when discharging 12,000 cu.ft. per sec.

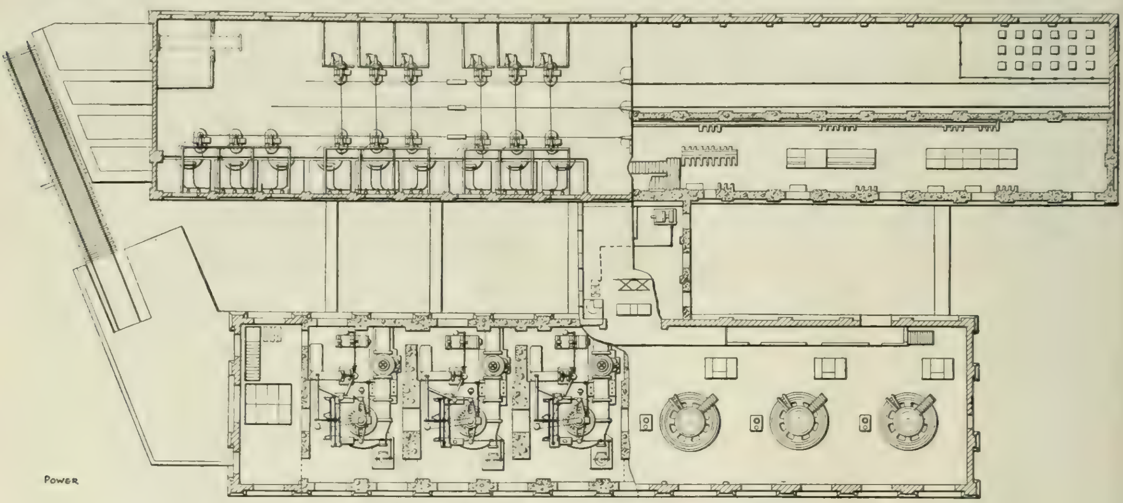


Fig. 13. Plan of Generator and Switch Houses

The flashboard counterweights are concrete cylinders 39 in. in diameter and 26 ft. long, and fitted at each end with a rack gear, which rolls on curved racks secured to the side of the piers above the crest of the dam. When the pressure of the water lowers the flashboards the counterweights are rolled up the incline by steel cables, which wind on a drum on the ends of the counterweights, and are connected at the other end to the top of the flashboards. The other four sections are to be fitted with built-up removable flashboards.

Another feature of this dam is the nine concrete piers, spaced 28 ft. apart, supporting a highway bridge, as shown. There is also a platform from which the flashboards can be operated by hand operated hoists if necessary. Fig. 2 shows a section through the main dam and spillway.

Tunnel and Penstocks

This dam creates a storage pond or forebay for the tunnel intake, which is built in solid rock from just above the dam to a point above the power plant. The intake head gates at the mouth of the concrete-lined, horseshoe-shaped tunnel are just above one end of the dam. The tunnel is 6670 ft. long with a net sectional area of 151 sq.ft. It discharges into a reinforced-concrete surge basin 96 ft. deep, 70 ft. long and 35 ft. wide. The walls are constructed of structural steel framework and concrete. From this basin five 5-ft. steel penstocks run to the power plant, 600 ft. below, which is built practically on the edge of the river bed in a deep gorge.

At the entrance of each penstock there is an emergency steel gate 7½ ft. square. The gates are hinged on a pin at the top side and held open by a chain- and hand-operated mechanism placed at the top of the surge basin.

At the upper end of the penstocks 60-in. remote-controlled, motor-operated valves are provided, Fig. 3, operated from the power house. Each penstock is anchored at the lower end by a cast-steel casing embedded in concrete. The anchorage is to take the thrust of the penstock and relieve the wheel casings of stresses. Each penstock, Fig. 4, contains an expansion joint just below the anchor blocks to take care of the expansion and contraction of the pipe line. Just outside of the switch house a venturi meter with a 35-in. throat is placed in each penstock, as in Fig. 5. The indicating and recording instruments are on a platform opposite the transformer bays in the switch house, Fig. 6.

Below each venturi meter is a hydraulically operated gate valve, 45 in. in diameter. The penstocks are fitted with an operating valve designed to be held in any position when the turbines are running. The head of water in the penstocks communicates with the cylinders and hydraulically operates the valves.

The penstocks are carried on concrete piers spaced about 30 ft. apart. Anchorage blocks of concrete are also provided at each change of grade for straight sections over 100 ft. in length. The maximum grade of the penstocks is 150 per cent. and the major portions are on grades exceeding 70 per cent.

Each penstock is made up of 400 ft. of riveted pipe, varying in thickness from 3/8 in. at the upper end to 9/16 in. at the lower, where it is joined to the 800-ft. length of the welded pipe, which is 9/16 in. thick at the upper end and 11/16 in. thick at the bottom.

POWER PLANT

The power station consists of two brick buildings, the main generating house and the transformer and high-tension switch house. The switch house is 28 ft. from the generator house. The latter is next to the river above the tailrace excavation in the river bed. The two buildings are connected by a bridge room in which is the switch-control apparatus.

In the generating building, which is 192 ft. long and 48 ft. wide, are five main generators, spaced 28 ft. apart, center to center, and space is available for a sixth unit. As would be assumed, the foundation is of heavy concrete, and the floor of the generator room is constructed of heavy steel beams to carry the weight of the generators. The roof of the building has a monitor extending nearly its entire length, and is covered by approximately 1200 sq.ft. of glass. The wall windows have steel sashes and glazed glass.

A 155-ft. gallery runs along one side of the generator room with a stairway at the ends to the generator floor. This gallery also forms the roof to the rheostat room.

The five main generators are of the vertical type and rated at 8000 kw., at 80 per cent. power factor, 6600 volts, 60-cycle, three-phase, and run at 514 r.p.m. On the dome of each generator is a 100-kw., 250-volt exciter, of a capacity sufficient to excite two generators at full load. A view of the generator room is shown in Fig. 7.

In the basement below the generator are the five 16,000-hp. vertical-shaft turbines of the Francis type, made by the S. Morgan Smith Co. They have, however, developed 18,600 hp. under test. These wheels are designed for a 600-ft. head of water. The speed is regulated by an oil-pressure governor with twin-gate-operated cylinders and a walking-beam to operate the gates. A partial view of the arrangement is shown in Fig. 8. The scroll case of each turbine is provided with a relief valve capable of discharging 70 per cent. of the water from the penstock in case of a sudden closing of the gate.

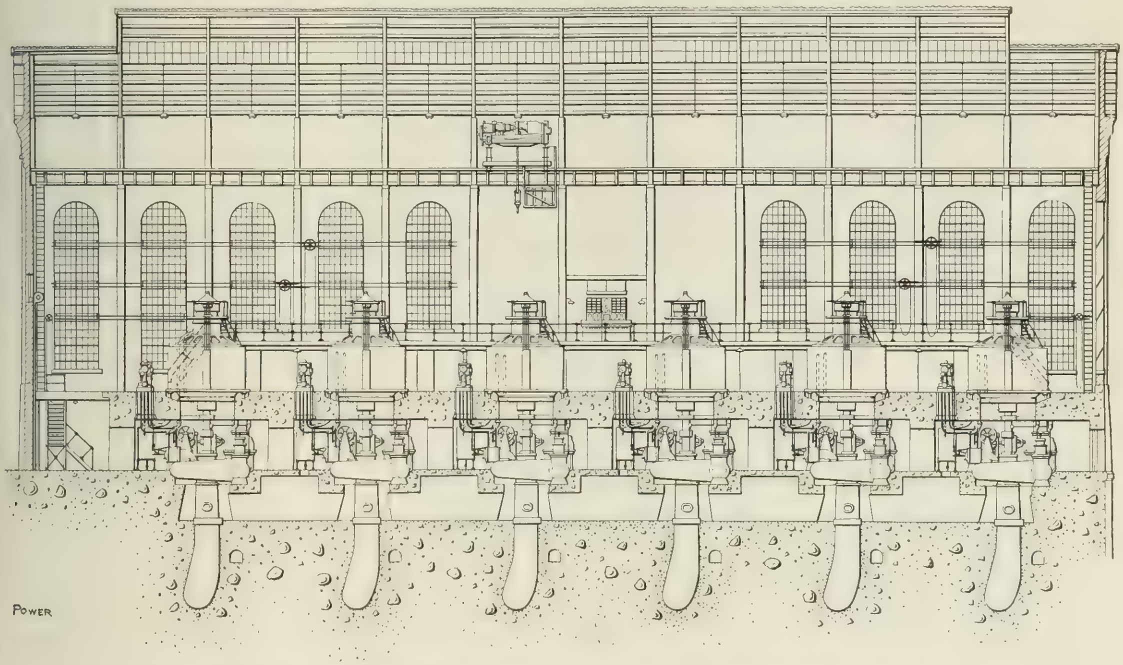


FIG. 11. SIDE ELEVATION OF THE GENERATOR ROOM AND WATERWHEEL BASEMENT

The wheel runners are of bronze and the gates of steel. Each wheel case has a 14½-ft. outside diameter and weighs approximately 28 tons. Water is discharged from the turbine wheels through steel-lined concrete draft tubes with a normal draft head of 22 ft. on the runner.

The vertical nickel-steel shaft, carrying the turbine runner and the revolving field of the generator, is supported by an oil-pressure thrust bearing at the upper end of the shaft between the rotor and the exciter generator. There is also a guide bearing below the generator rotor and one above the turbine runner. In the rear of the basement are two Goulds 4½x8-in. triplex pumps; one operating the governor, the other supplying the thrust bearing with oil. One is driven by a chain from a countershaft, which is driven by a worm gear and worm from the generator shaft. The other pump is driven by a geared 35-hp. motor. The thrust-bearing pump of each generator is so piped that any one can be operated with any generating unit.

The switch-control room, Fig. 9, which joins the generating and the switch houses and overlooks the generators, contains the instrument and integrating panels and a benchboard control of all service switches and signal lamps. The benchboard is laid out with miniature busses. On the main floor of the generator room under the control panels is one direct-current board upon which is mounted a remote-control field switch, operator's signals, etc.

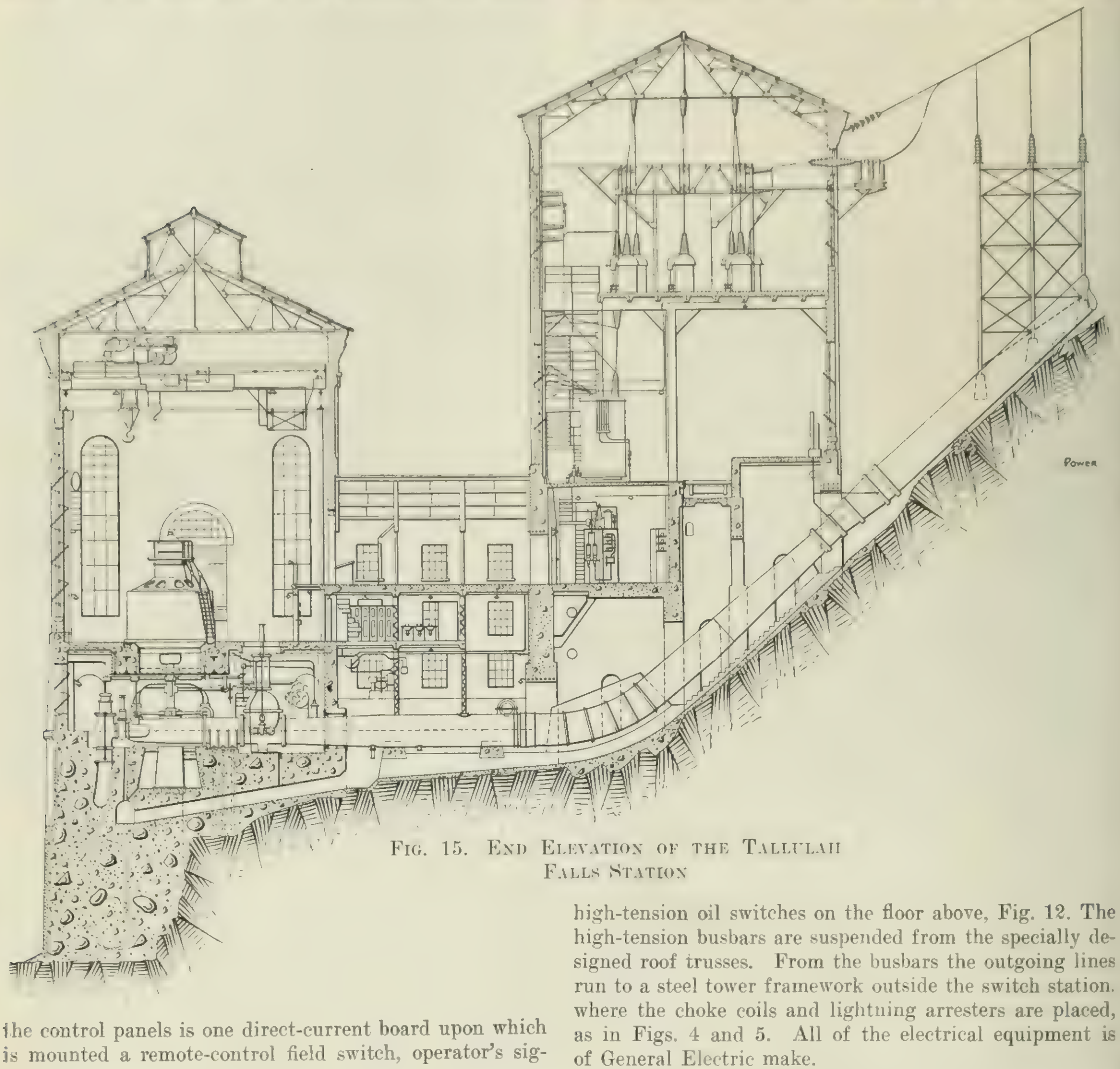


Fig. 15. End Elevation of the Tallulah Falls Station

Switch House

Passing from the control room to the switch building the low-tension busbar room is entered, where the busbars and oil switches are arranged in brick compartments and barriers, Fig. 10. Each generator is isolated from the other, and the low-tension transfer busbar is the only connection between the low-tension switch room and the generators, the cables of which run to the switch house, where the oil switches are placed in groups, as shown. The switches are connected through the busbars to the step-up transformers.

There are three 3333-kv. a. single-phase transformers per generator on the floor above the low-tension busses and switch room, Fig. 11, which transforms the voltage from 6600 to 63,500 and is sent out on the line at 110,000 volts. The transformers are delta-connected on the low-tension and star-connected on the high-tension side. From the transformers the electrical energy is carried to the high-tension oil switches on the floor above, Fig. 12. The high-tension busbars are suspended from the specially designed roof trusses. From the busbars the outgoing lines run to a steel tower framework outside the switch station, where the choke coils and lightning arresters are placed, as in Figs. 4 and 5. All of the electrical equipment is of General Electric make.

A plan of the generator and switch houses is shown in Fig. 13. Fig. 14 is a side elevation and Fig. 15 is an end section of the buildings. From these a comprehensive idea of the layout of the units, controlling apparatus and electrical equipment is obtainable.

Miscellaneous

It is not the purpose of this article to go into detail regarding the transmission lines leading from the power plant to Atlanta, 89 miles distant, where the largest outdoor substation in the world is located, Fig. 16. From

Atlanta the electrical energy is transmitted over steel tower lines to Lindale, Newnan, Gainesville and Cartersville, at which points are also outdoor types of substations. The transformers at the Atlanta station are water cooled, and the high-tension oil switches are the first of 110,000-volt capacity built for outdoor service. This substation has an ultimate capacity of 60,000 kw. in 110,000- to 11,000-volt transformers. At present there are nine 3333-kv.-a. transformers with a rating of 30,000 kw.

The hydro-electric station at Tallulah Falls is the largest strictly high-head installation in the Eastern half of the United States. It comprises the notable features of operating under a 600-ft. head using Francis type reaction turbines under the highest head in the South, if not in the country; furthermore, the turbine wheels are among the highest powered in the world. Charles O. Lenz, of New York City, designed and supervised the erection of the entire system, consisting of the main generating plant and auxiliaries at Tallulah Falls; and of the substations and connecting transmission lines.

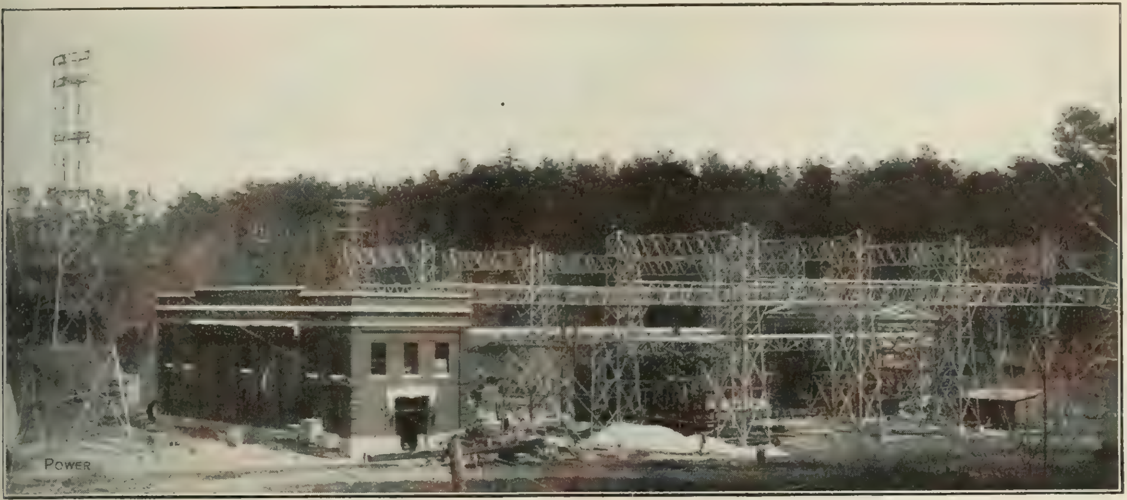


Fig. 16. Atlanta Outdoor Substation, the Largest in the World

⁂

Benefits from CO_2 Apparatus*

For the purpose of illustration, assume a stack temperature of 550 deg. F., and that air enters the furnace at 85 deg. F. With these conditions, the gases leave the heating surface 465 deg. above the temperature of the entering air. The specific heat of air is 0.24 and that of the gases approximately the same. Having these data, it is possible to get the approximate loss in B.t.u. per pound of gas that goes up the stack. Thus

$$465 \times 0.24 = 111.6 \textit{ B.t.u.}$$

is the loss in the present case. The percentage of CO_2 in the gas will tell how many pounds of air is used in burning a pound of carbon. With 18 lb. of air to 1 of carbon, there would be 19 lb. of gases going up the stack per pound of carbon burned, and the CO_2 reading should be about 14 per cent. The loss in B.t.u. would be

$$19 \times 111.6 = 2120.4$$

When the author first began to analyze the flue gases, the best-equipped furnace under his control showed 5 per cent. of CO_2. This indicates 50 lb. of air for each pound of carbon burned. The stack temperature was 550 deg. F. and that of the air entering the furnace 85 deg. F. As previously shown, this means a loss of 111.6 B.t.u. per pound of gas, so that the total loss up the stack per pound of combustible burned will be

$$51 \times 111.6 = 5691.6 \text{ B.t.u.}$$

For best results, there should have been 19 lb. of gas, the 32 lb. excess gas costing practically one-quarter of the fuel.

The boiler was new, and it seemed that there was little room for improvement before the CO_2 apparatus was installed. The foregoing figures only go to prove how deceiving appearances are and how important is the CO_2 instrument.

Finding it difficult to get the fireman to properly regulate the draft, the grate area was reduced to a point where high CO_2 readings could be obtained with the draft full on. Instantaneous readings then showed as high as 14 per cent. CO_2, but the average was about 8 per cent. This low average was caused by the fire-doors being open at the times of firing and cleaning, and often longer than necessary. There were about 60 sq.ft. of heating surface to one of grate area. The temperature of the escaping gases was around 460 deg., and that of the air entering the furnace about 85 deg. The fuel was Arkansas slack and the rate of combustion was about 20 lb. per sq.ft. of grate area.

Between the above temperatures the difference is 375 deg. and the loss in B.t.u. per pound of gas is 90. The CO_2 reading of 8 per cent. indicates that an average of 31 lb. of air per pound of combustible was used. The amount of heat going up the stack is therefore

$$32 \times 90 = 2880 \text{ B.t.u.}$$

Under the first condition the stack loss was 5691 B.t.u. per pound of combustible, and after making the changes the stack loss was 2880 B.t.u., a difference of 2811 B.t.u. Figuring carbon at 14,600 B.t.u. per lb., the saving amounted to 19 per cent.

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*Abstract of a paper read by Joseph McCrary before the Practical Refrigerating Engineers' Association, Dallas, Tex.

Sawmill Boiler Explosion at Miley, S. C.

By J. H. West

One boiler of a nest of four recently exploded at a sawmill plant at Miley, S. C., wrecking it, as shown in Fig. 1. The boiler was 60 in. in diameter and 16 ft. long, made up of six courses of two sheets each. The plates were $\frac{5}{16}$-in. thick, longitudinal lap joints, double-riveted with $\frac{3}{4}$-in. rivets with a 2-in. pitch; the girth-seam rivets were $\frac{3}{4}$ in., with a $2\frac{1}{16}$-in. pitch. Above the tubes were six diagonal braces from each head to the shell and three through braces. The dome was 30 in. in diameter, 36 in. high, with a $1\frac{3}{4}$-in. cast-iron head. The dome was riveted to the shell with two rows of $\frac{5}{8}$-in. rivets, $2\frac{1}{8}$-in. pitch, and was located over the girth seam between the second and third courses.

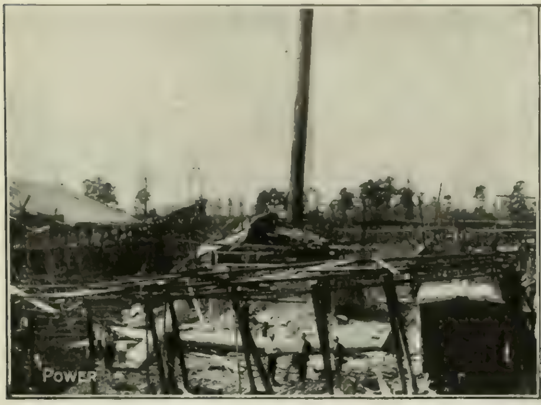
Fig. 1. Where the Boiler Exploded

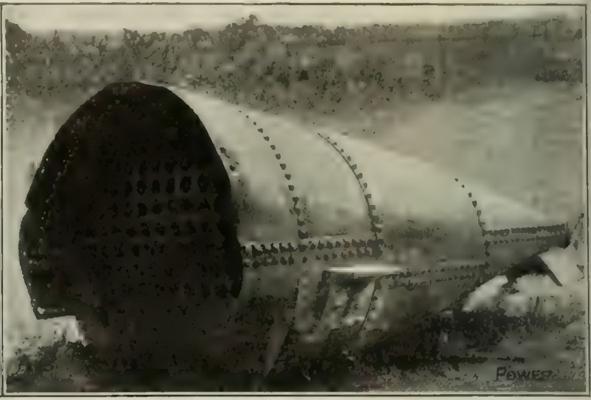
Fig. 2. Part of Boiler That Landed 1190 Ft. Away

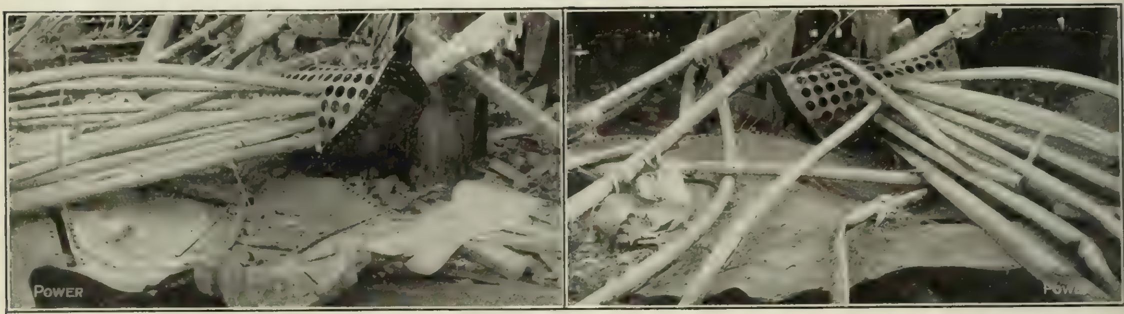
Fig. 3. Tubes, Tube Sheet and Torn Boiler Sheet

An 11x16-in. cast-iron manhole saddle was riveted on the fifth course of the shell with a single row of $\frac{5}{8}$-in. rivets, spaced $2\frac{1}{4}$ in. The opening through the sheet under the manhole saddle was $16\frac{1}{2}$x21 in.; the boiler had 92 three-inch tubes.

The boiler was fired up at 7 a.m. and exploded at about 11 a.m. The front head and the first three courses, remaining intact, passed over two rows of dwelling houses and landed 1190 ft. distant in a field, Fig. 2. All the tubes pulled out of the front head, and one of the through braces went with it. The remaining three courses parted across the sheet through the manhole, were straightened out, and landed, with the back head still attached by four rivets, against the side of the mill building, about 30 ft. away, Fig. 3. A few tubes remained in the back head, but the major part of them were scattered in every direction and over a considerable area, several going more than 500 ft.

The dome—weighing 675 lb., and evidently blown almost directly up—fell about 200 ft. away, rebounded through a shed and landed in an automobile. The condition of the dome indicates that it parted from the boiler first, as the flange is drawn down nearly straight in places. The rivets that held the dome to the shell remain in the sheet except three in the flange of the dome. They show no signs of shear; on the contrary, the shanks of the rivets project from the boiler sheet and the ends were jagged, the fibers standing up, showing that the heads were pushed off.

The rivets at the middle of the girth seam where the boiler parted were all sheared flush with the sheet, indicating that the boiler parted circumferentially at the instant the three rear courses tore across the sheets and through the manhole, as in Fig. 4. The section marked indicates a piece of the plate not yet found.

The adjoining boiler was thrown across a railway track, about 40 ft. distant and, while it had a dent in one side, was not much damaged. The water column and gage-glass remained unbroken.

A negro fireman was leveling the fire under this boiler at the time of the explosion and was blown some distance away, but except for a few slight burns, was uninjured.

The only fatality occurred between the boiler shed and mill building, where a negro laborer was literally blown to pieces, as was also the mule he was driving. Why more men were not killed is marvelous as the mill was being operated at the time.

There is none of the usual mystery surrounding this explosion; the boiler had been cut out the day before, and the main stop valve, between the boiler and the safety valve, was closed. A mill employee stated that on a previous occasion he had seen 180 lb. pressure on the steam gage, the stop valve being closed. The boiler must have been 25 or 30 years old.

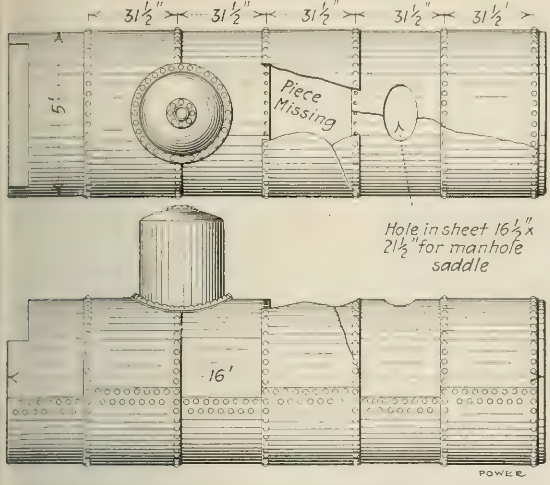

Fig. 4. Torn Portion of the Three Rear Sheets

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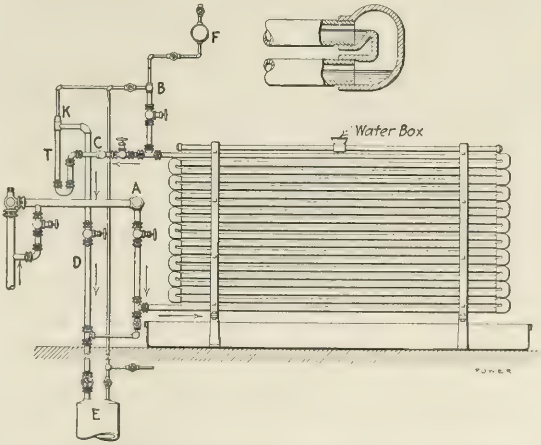
The Block Ammonia Condenser

Although the Block counter-current ammonia condenser has been on the market some little time, it is probably not familiar to all of our readers, and it may be of interest to repeat in part what Mr. Block himself had to say about the condenser at the recent meeting of the Eastern Ice Association in New York City. In general appearance it is like any other type of atmospheric condenser. It is made up of 2-in. pipe, usually 20 ft. long, and is from 16 to 24 pipes high, depending upon the temperature of the water used for condensing purposes. The feature in which the Block condenser differs from any other atmospheric condenser is that the liquid ammonia produced is for a time held in the pipes for the purpose of serving as a heat-transferring medium. The vapor enters the lowest pipe of the condenser, begins to condense as soon as the superheat is removed, usually in the third pipe from the bottom. The liquid ammonia now intermingles with the vapor and it travels forward and upward together at high velocity. As the vapor in the form of globules enters the liquid, each globule is surrounded by liquid and is itself condensing surface, giving up its heat to the liquid. The liquid in turn gives up its heat to the pipe through which it passes, and thus to the water flowing over the pipe. In the lower pipes there is much vapor and little liquid, but the proportion of liquid increases as the mixture travels forward, until finally all the vapor is condensed. A farther difference is that the condenser is a true counter-current apparatus, while other condensers are built on the parallel-flow principle.

The heat transfer from a gas through metal surfaces to a liquid is approximately at the rate of 60 B.t.u. per sq.ft. of surface per degree difference of temperature per hour, while the transfer of heat from a liquid to a liquid through metal surfaces is about 300 B.t.u. under the same conditions. The transfer from a mixture of vapor and liquid, such as is present in the Block condenser, to water flowing over the outer surfaces of the pipes is at the rate of from 180 to 200 B.t.u. per sq.ft. of surface per degree difference of temperature per hour. This explains why the Block condenser is from three to four times as effective as the ordinary type.

As the circulation of the ammonia is from the bottom of the condenser toward the top, the liquid ammonia leaves the condenser where the water is coldest and must therefore be cold itself. This is an important point when it is considered that liquid ammonia before evaporating in brine-cooling or direct-expansion coils, must first cool itself down to the temperature at which it evaporates.

Take the case of a refrigerating machine operating at 15 lb. back pressure, which is equivalent to a temperature of about zero Fahrenheit in the evaporating or brine-cooling coils. Assume that the temperature of the liquid ammonia coming from the condenser is 100 deg. F., then it is evident that the liquid must first be cooled down to the temperature of zero before it can begin to do effective cooling work. To bring about the cooling of the liquid, part of it must evaporate for that purpose only, and of the 572 B.t.u. of latent heat per pound of liquid there remains only 472 available for effective cooling work. The loss is nearly 18 per cent. If the liquid leaves the condenser at 70 deg. and is cooled down to zero, it will require only 70 B.t.u. for this purpose, and practically 500 B.t.u. will be available for effective cooling work, the loss in this case being a trifle over 12 per cent., making a net gain of 6 per cent. It is thus apparent that a machine making 100 tons of ice in 24 hr. under the first condition would make 106 tons of ice in the same period of time under the second condition without adding to the cost of operation.



Block Counter-Current Ammonia Condenser

It might be supposed that a certain effort would be necessary to push the liquid produced in the condenser upward through all the pipes and return bends, and thus increase the condensing pressure. This, however, is not the case, as the following explanation by Mr. Block will show.

Assume the water temperature as it flows on the upward pipe of the condenser to be 70 deg. F., and the temperature of the water leaving the lowest pipe of the condenser to be 85 deg. F. The pressure within the upper pipe will therefore be that due to a temperature of 70 + 10 = 80 deg. F., the difference of 10 deg. between the temperature inside of the pipe and the temperature outside being the usual allowance. The ammonia pressure due to a temperature of 80 deg. F. is 139.2 lb.

Within the lowest pipe of the condenser the temperature will be 85 + 10 = 95 deg., corresponding to a pressure of 182.6 lb. The difference therefore between the pressure in the upper and lowest pipe of the condenser is 43.4 lb. This pressure is quite sufficient to induce the mixture contained in the condenser pipes to travel forward and upward in spite of the friction which must be overcome, without any extra effort on the part of the compressor. As a matter of fact the friction absorbs nearly all of this excess pressure. In practice it has been found that a slight difference in pressure exists between the upper and lower pipes; a difference of as much as 3 lb. has been observed by Mr. Block.

In the accompanying drawing of the condenser, *A* is the hot-gas header from which the gas, or rather vapor, travels downward and enters the bottom of the condenser. It then travels back and forth and upward, and when it reaches the second or third pipe from the top all of it has been converted into liquid, which leaves the condenser through the top pipe and enters the liquid header *C*. The liquid flows through trap *T* and down pipe *D* to the liquid receiver *E*, the trap being inserted for the purpose of preventing the accidental discharge of unliquefied vapor, due to a momentary interruption of the water supply or for other reasons. At *B* is the equalizing header, which is connected to every coil of the condenser, and *K* is a siphon-breaker on top of trap *T*, which connects with the equalizing header *E* and prevents the discharge of the liquid in jerks, thus insuring a uniform flow. An air drum *F* is also connected with the equalizing header. Air and noncondensable gases will automatically collect in this drum, and if it is desired to purge the condenser occasionally it can be done during operation.

To do three times as much work with one of these condensers as with another type, it is necessary to supply three times as much water. The Block condenser does not require less water than any other to do a stated amount of refrigerating work, nor does it require more water. If 150 gal. of water per minute are charged over seven or eight condensers of the ordinary type in order to condense all the vapor discharged by a 100-ton refrigerating machine, then it will require 150 gal. of water per minute to do the same amount of work with three Block condensers, the difference being that the water heretofore distributed over the seven or eight coils of the ordinary type must now be distributed over three coils of the Block type.

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Plant vs. Purchased Power in Department Store

By F. W. Rose*

SYNOPSIS—Complete power-plant costs of a large department store affording an actual comparison between the costs with central-station service and a private plant which was later installed.

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The Emporium department store, of St. Paul, Minn., is a four-story and basement fireproof building, having a cubical content of 1,950,100 cu.ft., and a floor area of 125,000 sq.ft. The heating is mainly by direct radiation, a one-pipe gravity system with a Paul air line being employed.

The basement and first floor have a ventilating system in addition to the heating system, consisting of two steel-plate fans, each having a capacity of 35,200 cu.ft. per min. The two fans are driven by a 10x12-in. horizontal, center-crank engine. In the tempering coils there are 2272 sq.ft. of radiation, and in the heating coils 3040 sq.ft. The air is drawn through an air washer having a capacity of 75,000 cu.ft. per min.

When the building was built in 1909 a boiler plant was installed and provisions were made for a generating plant which was put in service one year later. The boiler plant consists of three 200-hp. water-tube boilers with Murphy stokers, duplicate boiler-feed pumps, open feed-water heater and the usual auxiliary equipment. The building has its own water supply, consisting of a steam pump which takes water from a deep well and delivers it to a pressure system.

The generating plant consists of a 100-kw. and a 200-kw., 250-volt, three-wire, direct-current units, driven by side-crank, tandem-compound, noncondensing engines. These were put in operation in September, 1910, which was the expiration of the contract for central-station service. In the summer of the following year a contract was made with the central-station company for emergency service and night lighting, which has been in force ever since.

TABLE I. POWER-PLANT COSTS—1909-1910

Month 1909	Cost of Purchased Current	Kilowatt Hours Generated	Cost of Coal	Loads of Ash	Cost Miscellaneous Supplies	Labor Cost	Total Monthly Cost
Sept.	$1050.00	......	$136.71	....	$12.00	$225.00	$1423.71
Oct.	1050.00		142.68		14.00	225.00	1431.68
Nov.	1050.00	. .	398.97	...	13.50	225.00	1687.47
Dec.	1050.00	......	950.60	....	12.00	225.00	2237.60
1910							
Jan.	1050.00	....	668.41	...	10.00	225.00	1953.41
Feb.	1050.00	.....	406.41	....	10.00	225.00	1691.41
Mar.	1050.00	. ..	414.81	....	10.00	225.00	1699.81
Apr.	1050.00	......	163.70	....	10.00	225.00	1448.70
May	1050.00	......	247.69	....	11.25	225.00	1533.94
June	1050.00	......	274.80	....	11.25	225.00	1561.05
July	1050.00	......	239.64	....	10.00	225.00	1524.64
Aug.	1050.00		174.57	....	11.00	225.00	1460.57

In September, 1912, an addition to the store was opened to the public. The cubical content of this addition is 1,316,470 cu.ft. and the floor area is 85,440 sq.ft., giving a total of 3,266,600 cu.ft. and 210,440 sq.ft. respectively, which is an increase of 67 per cent. No change was required in either the boiler or generating plant to take care of this addition and there is capacity for still further extension.

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*Consulting engineer, Minneapolis, Minn.

At present there are 21 motors in the store, having a total rating of 193 hp. Six of these are on passenger elevators, one on a freight elevator and one on an escalator.

Very accurate records have been kept and the data in the tables were taken from these records. Tables 1 and 2 show respectively the costs for the first year, 1909-1910, when central-station service was employed exclusively, and 1912-1913 when using the private plant with purchased current for night lighting. Table 3 gives a comparison of costs for the four years that the store has been in use.

TABLE II. POWER-PLANT COSTS—1912-1913

Month 1912	Cost of Purchased Current	Kilowatt Hours Generated	Cost of Coal	Loads of Ash	Cost Miscellaneous Supplies	Labor Cost	Total Monthly Cost
Sept	$150.48	23,460	$552.53	15	$5.06	$332.66	$1040.73
Oct.	112.31	28,580	462.42	19	17.85	392.66	985.24
Nov.	122.88	31,660	748.55	18	34.10	392.66	1298.19
Dec.	106.32	41,200	433.54	24	33.10	382.66	955.62
1913							
Jan.	50.88	42,400	639.18	28	22.21	414.00	1126.27
Feb.	36.00	38,030	1049.64	23	18.60	414.33	1518.57
Mar.	66.48	35,630	850.92	25	51.55	386.33	1355.28
Apr.	105.60	30,530	385.02	20	8.38	359.33	858.33
May	106.32	31,000	320.85	24	37.73	359.33	834.23
June	108.24	26,200	683.15	18	22.70	353.33	1167.42
July	94.32	24,190	215.51	18	14.60	353.33	677.76
Aug.	100.08	25,450	503.28	16	24.00	353.33	980.69

The ash is removed by the company's teams and no charge is made, but in figuring these costs an allowance of 50c. per load was made, as a record of the number of loads has been kept for each year except the first, and for the first year the cost of removal of ash was taken as the same percentage of the cost of coal as in the other three years.

TABLE III. POWER-PLANT COSTS FOR FOUR YEARS

Year	Cost of Purchased Current	Kilowatt Hours Generated	Cost of Coal	Cost of Ash Removal	Cost of Miscellaneous Supplies	Labor Cost	Lost Rent, Interest, Depreciation, Taxes, etc.	Total Costs	Cost Less Purchased Current	Cost per Cubic Foot	Cost per Square Foot
1909 and 1910	$12,600.00	....	$4,218.99	$76.79	$135.00	$2700.00	$2835.00	$22,565.78	$9,965.78	1.157 cents	18.05 cents
1910 and 1911	498.08	336,110	11,638.90	198.50	422.45	4284.00	4785.00	21,826.83	21,328.85	1.119 cents	17.46 cents
1911 and 1912	1,694.60	389,569	7,405.73	149.50	304.38	4110.58	4785.00	*17,786.94	16,092.34	0.912 cents	14.23 cents
1912 and 1913	1,159.91	378,330	6,854.59	124.00	289.88	4493.95	4785.00	17,717.33	16,547.42	0.542 cents	8.41 cents

* Net cost after deducting $662.85 representing charge for steam, water, electricity and labor use during construction work on addition to building.

The lost rent charged against the space taken up by the plant was figured at 30c. per sq.ft. per year. Interest, depreciation, taxes, etc., were figured at 12 per cent. on the plant investment and 6 per cent. on the added cost of the building on account of the plant.

It is interesting that the total costs for the last year, with the 67 per cent. increase in the store space, are less than any of the preceding years, and much less than the first year when central-station service was used. This is accounted for in a very large measure by the careful watch kept by the chief engineer, W. G. Lyon, for all opportunities of reducing the cost of operation without impairing the efficiency of the results, and by the larger load factor on the plant which results in higher efficiency. This is especially true of the boiler plant, as only one boiler has ever been used at one time even with the increased building. Another thing which has reduced the costs was the changing of lamps. When the store was first opened, a large number of arc lamps which had been used in the old store were installed. These lamps have all been replaced by large tungstens, carbon lamps have been replaced by tungstens and in places where smaller lamps would give satisfactory results, the smaller lamps have been used.

Compressed-Air Starters

By A. L. Brennan, Jr.

During the experimental stages of self-starters, compressed air was used extensively and proved entirely reliable; but designers soon found that along practical lines it was adapted only to heavy power units. This was principally because on motor cars and boats the space available is often limited and since the first requirement of a mechanical or functional self-starter is compactness, this condition could not always be had when using a system that is not self-contained.

The component parts of a compressed-air system consist of a valve mechanism or distributor for controlling the air to the cylinders, suitable piping, air compressor, and storage tank for air. A tank holding air sufficient to start even a small multicylinder motor several times without recharging must be of fair size and consequently takes up considerable room. Some argue that a tank holding sufficient air to start the motor once is sufficient. This is poor practice, for, unless the tank is of sufficient volume to start the motor several times without recharging, any one of the several complications liable to take place when starting will render the self-starter inoperative. Little difficulty is encountered when installing this type of self-starter in stationary plants for the room required for suitable storage tanks is usually a secondary consideration.

The first cost of a compressed-air system is usually low and the operating and maintenance cost is small; also it requires little attention. In regard to the correct installation of such a system the following suggestion will be found of value.

Instead of using one large tank for the storage of the compressed air, two tanks should be used, one large and one small, fitted with suitable piping and valves to regulate the admission and release of air from either or both tanks. This will allow the compressor to feed air to either or both tanks and the small tank can be held for emergency purposes. A hand pump should be connected to the small tank, thus affording an auxiliary pumping system. If the joints are made up well with shellac and suitable valves are placed at the tanks, the air pressure should remain almost indefinitely.

Some air-starting mechanisms are controlled by a distributor which operates on the same principle as a timer which governs the flow of electricity to a spark plug. This method has proved entirely satisfactory and is to be found on several motors of various sizes. On other engines the direct-valve system is employed, the valves being controlled by a shaft which, when shifted, engages with the inlet compressed-air valve stems and causes the valve to open and admit compressed air to the cylinder last under compression, thus forcing the piston down, since both intake and exhaust valves are closed. The air valve is closed when the piston reaches the bottom center of the stroke and a similar set of operations take place in the next cylinder in the order of firing. The same operations take place in connection with a distributor starter, the only difference being that the air is admitted by the distributor "uncovering" instead of a valve opening.

Since both inlet and exhaust valves are closed during the admission of the compressed air, the efficiency of the mixture is not impaired for the reason that the air is not admitted to the cylinders until the pistons have passed the point of firing. The "direct valve" method appears to hold favor on large motors, although it must not be conceded from this that the disk distributing valve is not dependable.

The chief difficulty encountered with automatic air starters is attributable to loss of pressure which in turn can be traced to poor check valves, faulty joints in the pipe line, distributor or valves leaking, worn or scored compressor cylinder, or the compressor piston or rings worn or broken.

Air leaks are usually easy to trace if undertaken in a systematic way. The writer has found an old shaving brush and a piece of shaving soap convenient for locating leaks of this nature. By painting the joints of the pipe line and other parts likely to leak with soap suds, a leak is easily detected and in fact very slight leaks can be found in this way which would otherwise go unnoticed. Care should be exercised when making up joints that the pipe fittings take hold for at least four or five threads. Shellac is undoubtedly the best medium to use for all air-line joints and should be applied evenly to both sets of threads and the joint set up firmly at once. Joints so treated will stand vibration without leaking.

Grinding is about the only positive remedy for a leaking valve. Valve grinding may be considered an art in itself, but the novice can get good results by following a few simple rules: Never attempt to grind a valve without first removing its "seating" spring for otherwise both the valve face and its seat are likely to be deeply scored. Never grind a valve by revolving it one way, but alternate, revolving the valve two or three times in one direction and then two or three times in the opposite direction. When changing the direction of rotation, lift the valve from its seat, turn a quarter and again seat, this will cause other particles of the abrasive to cut and prevent scoring or cutting in one place. Never use a dry abrasive except the very fine powders for finishing. Grinding is greatly facilitated by playing a spring under the valve head that will cause the valve to leave its seat when relieved of the pressure exerted when grinding. The valve should be ground against its seat until both have a bright even surface which will insure an air-tight union.

Starting troubles which prevent a gas engine from picking up its cycle when hand cranking is employed will likewise result in a non-start of motors fitted with self-cranking devices, therefore, if a motor is turned over by an auxiliary means and does not start within thirty seconds, this is, usually, a positive indication of existing trouble.

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Big Western Development—The Stone & Webster Corporation, Boston, Mass., has a representative in Seattle, Wash., completing arrangements for starting work on the development of 85,000 hp. for the operation of electric car lines and power purposes. The company recently acquired rights to the Skagit and Cascade rivers and their tributaries. Plans are being completed in the company's Eastern office and will be ready for starting of work the first part of the year. The development will cost about $6,000,000.

Instruction in Refrigeration

By J. S. A. Johnson*

The writer was greatly interested in a Power editorial of Oct. 28, 1913, in which an appeal was made to engineering schools to offer thorough courses in refrigeration.

In the course in mechanical engineering at the Virginia Polytechnic Institute, three class periods per week for one term are devoted to refrigeration, while the theory of the subject is covered in thermodynamics. In addition to the class work, a laboratory course is given which includes the testing of compression and absorption plants.

The quantities of brine, cooling and condensing water, coal, steam, electrical and mechanical work, and temperatures of brine, ammonia and water, are obtained in the usual manner, by weighing or measuring. The quantity of anhydrous ammonia is got by the use of two accurately calibrated measuring receivers, provided with gage-glasses having graduated scales, and connected in a by-pass to the main anhydrous ammonia line. While one receiver is filling, the other is being emptied. A correction has to be made in the apparent volumes of anhydrous ammonia consumed on account of the vapor generated (in the receiver which is being emptied) from the liquid which was in that receiver after the closing of the inlet valve. For instance, when receiver No. 1, Fig. 1, is emptied of liquid from level *A* to level *B*, the actual weight of liquid leaving the vessel will be

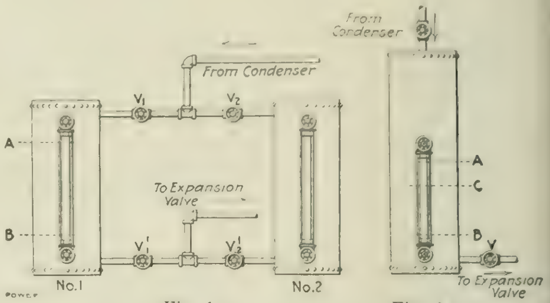

Fig. 1 Fig. 2

Fig. 1. Receivers of Compression Plant
Fig. 2. Absorption Plant Receiver

$$(W_1 \times V) - (W_2 \times V)$$

in which expression, W_1 is the specific weight of the anhydrous ammonia (liquid) at the given pressure, W_2 the specific weight of saturated vapor at the same pressure and V the volume included between the levels *A* and *B*. From calibration curves, the total volumes used in a test may be determined.

The compressor is of the vertical, two-cylinder, single-acting, belt-driven type. The cylinders are tapped and provided with special valves for the attachment of indicators so that the clearance will be a minimum while diagrams are being taken.

The quantity of anhydrous ammonia used in the absorption plant is calculated from observations on the total weight of strong liquor circulated, and the percentage strengths of the weak and the strong liquors. A cooling coil is provided for sampling the weak liquor, the temperature of both weak and strong liquors being reduced to 60 deg. F.

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*Professor of experimental engineering.

As a check on this method, observations are also made on the main ammonia receiver (in the absence of the two auxiliary measuring receivers) which stands vertically, and is provided with a gage-glass and graduated scale. Referring to Fig. 2, the level of the ammonia being at A at the beginning of the test, and a constant flow of ammonia from the condenser being maintained, the valve V (not the expansion valve, which is kept at constant opening) is opened, and the level of ammonia will drop to B in time t_1. After valve V is closed (level at B) the receiver will fill to level C in time t_2. If V_c represents the volume of ammonia between B and C, the quantity of ammonia generated in time t_1, while the receiver was emptying from A to B, will be very nearly equal to

$$\frac{V_c}{t_2} \times t_1$$

Or, letting the odd subscripts refer to times of emptying, and the even to filling, the quantity of ammonia generated during a given period of emptying will be

$$\tfrac{1}{2}\left(\frac{V'}{t_n} + \frac{V''}{t_{n+2}}\right) t_{n+1}$$

n being an even number and the corresponding time interval being a period of filling. By adding these amounts to the amount apparently discharged while emptying, the total volume of ammonia generated during the test may be ascertained with possibly greater accuracy than by a calculation involving the total weight of strong liquor circulated.

The weight of steam consumed in the still, or generator, is measured after discharge through a trap and cooling coil.

From the absorption plant, the ammonia liquid (anhydrous) is conveyed several thousand feet to the rooms to be refrigerated, while in the compression plant the transmission line is comparatively short.

Both plants afford excellent opportunities to the students for testing and observation, and the course in refrigeration meets with much favor.

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Solving the Cinder Problem at Waterside--I

By Charles H. Bromley

SYNOPSIS—Being the first of a series of articles treating of the apparatus and methods used to catch the cinders in the flue gases at Waterside stations Nos. 1 and 2 of the New York Edison Co., New York City. The problem extends back over a number of years and various experts have worked on it. The first scheme was to precipitate the cinders by reducing the velocity of the gases, but this proved futile. Next, settling chambers, baffles, screens, water sprays, etc., were tried. Finally, high gas velocity with sharp changes in direction of flow and impingement on films and surfaces of water proved successful. A special cinder-producing plant was erected to try out various cinder-catching apparatus. This series of articles deals with the evolution of the cinder problem at Waterside, describes the various apparatus used and the conditions met, the purpose being to show what are and are not successful apparatus and methods so as to point out the strong and weak points in cinder elimination, and show what apparatus may work successfully in ordinary plants where the coal consumption is much less than at Waterside.

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Difficulty of Solving the Cinder Problem

Suppose you had all the money you needed to hire experts, to erect flues with numerous kinds of baffles, water sprays, fans—to even erect a special cinder-producing

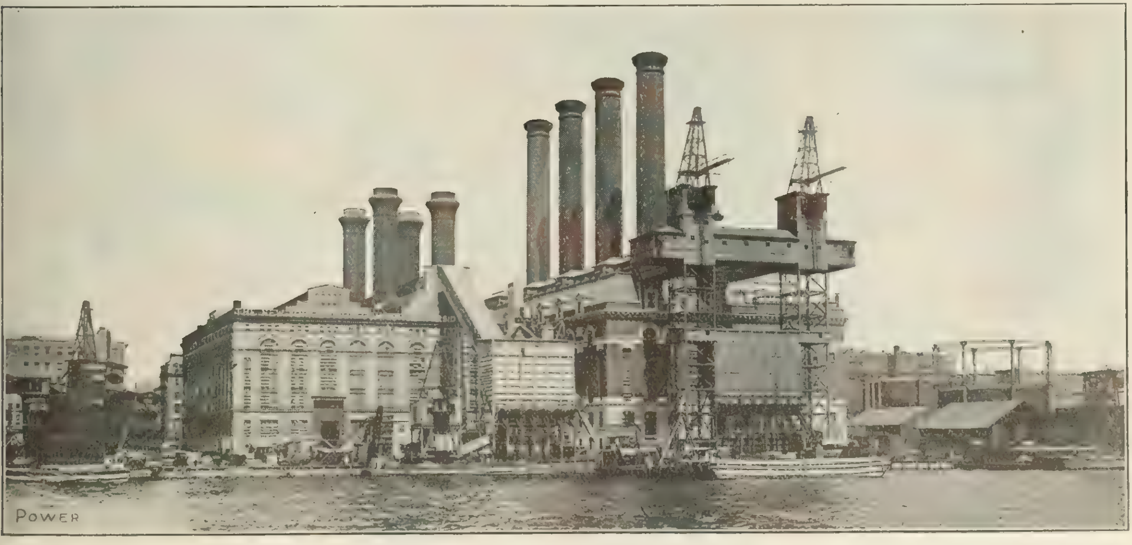

Fig. 1. The Waterside Stations of the New York Edison Company

plant to try out apparatus, in fact, suppose you had all the resources imaginable to enable you to take cinders out of smoke. Easy! You would conclude that you had the greatest "cinch" of the age. But you would not. The New York Edison Co. had and has all those things and has spent years in trying to solve the problem and knows.

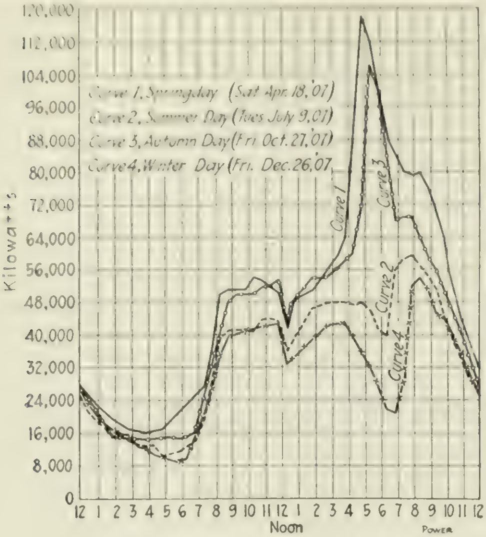

Fig. 2. Typical Season Peaks

Numerous experts have exercised their skill and talent on the problem and have failed.

The Edison company's engineers have finally developed a successful cinder-catching apparatus which will be described in this series. The present article deals with conditions as they existed during the growth of the cinder nuisance.

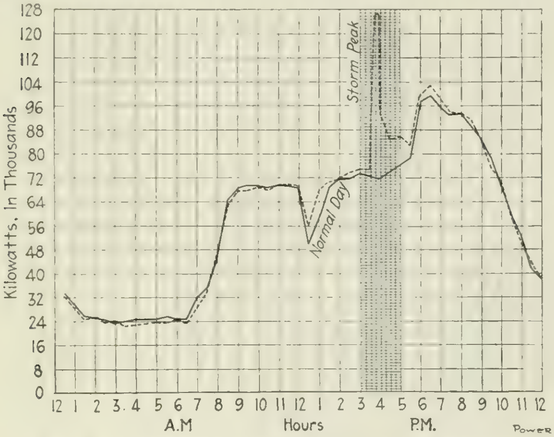

Fig. 3. Increase of 52,000 Kw. in 20 Minutes

From Hand- to Stoker-Fired Furnaces

Back years ago when the Pearl St. plant was the company's principal station, hard coal was cheap, so cheap that not a pound of soft coal was ever burned there. But as the business grew and Waterside station No. 1 was built, soft coal was used in 26 boilers. Fig. 1 shows the Waterside No. 1 and No. 2 stations. The boilers were equipped with stokers which the manufacturers guaranteed would meet the load conditions and produce practically smokeless combustion. Despite this guarantee the smoke complaint became so serious that neither the engineers for the stoker makers nor the Edison engineers could stop or reduce it.

Back to Hand Firing

The stokers were discarded and the company went back to hand firing, burning No. 3 buckwheat coal on stationary grates, a practice not uncommon where smoke ordinances are enforced. While the use of hard coal eliminated the smoke trouble, yet its use resulted in new difficulties, owing to the production of cinders.

A New Stoker Is Developed

At this time a now well known stoker was in its experimental stage, and the Edison company believed it could develop it to meet its needs and thus end the cinder evil by burning a mixture of hard and soft coal. This was done and the stokers installed in reconstructed furnaces with special arches. Owing to rapid increase in coal consumption, due to a continuously growing load, the trouble became greater instead of diminishing.

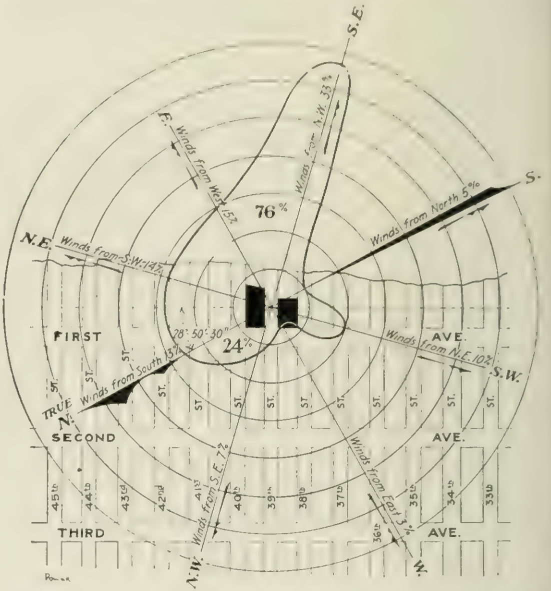

Fig. 4. Wind Rose; Waterside Stations in Center

Load Increases 52,000 Kw. in 20 Minutes

An idea of the load conditions is gained from the load curves for the different seasons, as shown in Fig. 2. Note that the curve for Apr. 18, 1907, shows a rise of 54,000 kw. in one hour, which means that the fires under the standby boilers were suddenly disturbed, the draft increased and the production of cinder made much greater as a result. Not long ago these Waterside stations took on nearly 52,000 kw. in 20 min., due to a sudden shower increasing the demand. Fig. 3 shows this curve contrasted with a normal day curve. And so these peaks come and go, and make the smoke and cinder problem difficult of solution.

Fig. 4 is a wind rose, showing the directions and dura-on in time of winds, and the distribution of cinder. The aterside stations are in the center, and the clear open pace above the irregular horizontal line represents the ast River. The prevailing winds are northwest, coming om that direction 33 per cent. of the time. West winds re next highest, blowing for 15 per cent. of the time.

The rose also shows that 76 per cent. of the cinder nitted from the stacks is blown into the river, due to he prevailing winds from the northwest. The other ortion represents the area within which the remaining 4 per cent. of the cinder was distributed. This rose hows that less than one-quarter of the cinder emitted was eposited in an area from which complaints came. This act indicates what a large amount was blown from the tacks, when less than one-quarter of it caused the proests that have been made. It is from a study of this ind rose, perhaps, that one can best appreciate how erious this cinder problem really is, or rather was; since successful catcher has been devised.

Next week's article will describe the boiler and flue rrangement at Waterside and illustrate the settling hambers and some of the apparatus used and will tell hy it failed.

The Diesel Engine in Marine Service

Georges Carels, the well known Diesel-engine builder, n an address before the North-East Coast Institution of ngineers and Shipbuilders,* gave a sane and most comprehensive review of Diesel-engine practice as now aplied to marine work.

Admitting that the progress of the Diesel engine in his field has been slow, he attributed this partly to the igh price of oil and partly to a reaction from the extreme ptimism of the Continental press, most owners of vesels preferring to wait and observe the experience of those notor ships now in service rather than join the pioneers.

He strongly condemned the practice of some firms in ttempting to put Diesel engines on the market without xtensive preliminary tests backed up by the necessary xperimental work. As a result of this, many troubles ave developed, but these, he believed, served a useful urpose in showing how not to build Diesel engines.

The demand a few years ago for light-weight, highpeed engines was productive of a great variety of designs, n many cases unreliable, and the present tendency is to revert to slower speeds and to fewer types.

Regarding the relative merits of the two-stroke and four-stroke cycles, Mr. Carels had this to say, first considering the high-speed types:

1. The two-stroke-cycle engine is safer because it has no exhaust valves.

2. The reversing gear with the two-stroke cycle is simpler.

3. Comparing engines of the same power and the same number of cylinders, the two-stroke-cycle engine has the more uniform turning moment.

4. The mean temperature is higher in the two-stroke cycle.

5. It consumes more fuel and lubricating oil than the four-stroke-cycle engine.

6. Its mean effective pressure is lower; therefore, a high-speed, two-stroke-cycle engine is not necessarily lighter than a high-speed, four-stroke cycle.

Comparing slow-speed engines of both cycles reverses the case. Here it is possible to obtain a mean effective pressure equal to or higher than that of the four-stroke cycle, therefore, the slow-speed, two-stroke-cycle engine can be made lighter and cheaper than the four-stroke-cycle engine of the same power and speed. The fuel consumption is, in the former, a function of the speed of the engine. At slow speed it is only about 10 per cent. higher than in the corresponding four-stroke-cycle engine; the same remark applies approximately to the lubricating-oil consumption. Points (1), (2), (3) and (4) still apply.

With regard to slow-speed, two-stroke-cycle engines with scavenging valves and those having ports, Mr. Carels pointed out that, although the latter have the advantage of greater simplicity, the scavenging is less perfect. These features were thus summarized.

In all cases where simplicity and robustness, combined with maximum reliability, are the essential factors, and where the fuel bill is of secondary importance, the valveless two-stroke-cycle is recommended. In those where the fuel economy is the essential factor, but high speeds are necessary because of space and weight limitations, the four-stroke-cycle engine is preferable; this applies to electric-lighting sets for ships, etc. For all high-powered, slow-speed engines for land and marine purposes—say, from 1000 hp. upward—the two-stroke-cycle engine is to be preferred. This is the real domain of the two-stroke-cycle engine, where its advantages can be fully brought out.

Taking up features of design, Mr. Carels emphasized the necessity for considering not only direct transmission of forces, but also those due to expansion in all parts subject to high temperatures—a fact which makes the problem much more complex than in the case of the steam engine. Due to the high transmission of heat through the walls of the combustion chamber, only special grades of cast iron are suitable for these parts, and it is highly desirable that more extensive study be given to the question of appropriate cast irons for this service. All such parts should be very accurately machined, the clearances exactly determined and the relative degree of wear closely followed.

Of pistons, Mr. Carels expressed preference for the crosshead type rather than the trunk type, because the latter is called upon to fulfill the double requirement of taking the side pressure of the connecting-rod and yet remaining gas-tight. While trunk pistons have been used successfully in many medium-sized engines, cases of gripping have nevertheless occurred from time to time.

A part that needs careful attention is the fuel valve. Not only should the needle and valve seat be removable in a minimum time, but this should not make resetting of the valve-gear afterward necessary. Consideration should be given to the influence of expansion of the needle and valve-gear on the timing and the design should be such as to avoid sticking of the needle. Also the starting valve should be so designed that it cannot rust in its casing. Sticking of the starting valve has frequently given rise to trouble.

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*For a complete report of this paper see "The Engineer," Dec. 5, 1913.

In this connection, the speaker suggested that some means be provided for grinding the valve on its seat from time to time while the engine is running.

As to the frequent capriciousness of fuel pumps, Mr. Carels laid down the features that should be followed. Air pockets should be absolutely avoided; valves should not be given too broad a seat; the fuel must be very finely filtered, and the fuel pipe from the pump to the fuel valve must be as short as possible. In marine engines, as the possible reduction of the number of revolutions at slow speed is largely dependent on the same amount of oil being given to all cylinders, there should be a separate plunger for each cylinder and not a fuel distributor. Here also the suction and discharge valves should be easily removed and replaced.

In Mr. Carels' opinion, many made the mistake of oiling their compressors too profusely, or allowing too much to enter the compressor cylinders, and then providing insufficient or no means of separating that oil after each stage of compression; also in not sufficiently intercooling the air. The air must be cooled immediately after the discharge valve of each stage. Long, uncooled pipe strains between the compressor and the cooler should always be avoided and the receivers should be large. It must not be forgotten in calculating a compressor that the air in each stage must reach a pressure considerably higher than the receiver pressure to open the valves, and the number of stages must be so chosen that the final temperatures shall not be high enough to cause ignition of the oil vapors carried in the air.

On the other hand, safety valves should be placed immediately after the discharge valves and not at the coolers or receivers, because an explosion propagating in a long pipe produces a local rise in pressure sufficient to blow it up long before the explosion wave reaches a safety valve placed further on.

The air bottles should be provided with sufficient drainage conveniently located, the best method being to provide a continuous blowoff.

One more important point taken up was the crankshaft, which should have a high factor of safety; the diameter being about 0.6 that of the cylinder. A short, stiff crank withstands torsional stresses best and the bearings should be preferably short.

Hot-Water Boilers vs. Live-Steam Heaters

The reply by Ira N. Evans to the following question of a reader in England may be of general interest.

"In POWER of July 18, 1911, I. N. Evans states that it is very difficult to regulate the fire under hot-water boilers on account of the wide variation of the outside temperatures. Do I understand this occurs if temperature-controlled dampers are used? I should like to see an opinion of an authority like Mr. Evans if he considers it more economical to utilize, say, three existing Lancashire boilers for heating approximately 60,000 sq.ft. of radiation and circulate the water in series through exhaust-heated closed heaters and then through the necessary number of Lancashire boilers to add the extra heat required, or to utilize the boilers as steam producers and install the necessary live-steam closed heaters."

Using hot-water boilers on a system of heating using forced circulation rather than a live-steam heater is a question of investment and number of fires necessary rather than one of economical transfer of heat from th fuel.

In case a live-steam heater is used and the steam circuit broken between the heater and boiler, either by drai traps or pump and receiver, a loss of 10 to 15 per cent is possible. Where a gravity return is maintained or th circuit sealed the live-steam heater arrangement shoul prove the more economical.

When power and heating are required, if both ho water and steam boilers are used, reserve capacity of bot types has to be maintained for each branch of the servic If all of the boilers generated steam at the same pressure they would be interchangeable and there would b less liability of putting extra units in commission t handle the peaks of both branches of the service. If th power and heating were balanced during the peak powe load, exhaust steam would be available for heating th balance of the time, and when the exhaust was insuff cient the same boilers could supply the live-steam heate Hot-water heating boilers are idle in summer, which another distinct disadvantage.

In a recent handbook on heating an arrangement h been diagrammed in which power boilers are connecte so as to be used as steam or water boilers. This in th writer's opinion is dangerous, as only one, or perhaps several, valves separate the circulating water in the heatin system from the high-pressure steam in the boilers whe so operated. It can be imagined what would happen the fireman should open the valve by mistake.

With a high-pressure steam boiler a reduction in lo causes the pressure to rise, closing the damper, and th steam and water in the boiler form a storage for the su plus heat of the fire. The latent heat in steam gives rapid relief when the boiler blows off and the boiler mo rapidly adjusts itself to sudden changes in load.

The temperature in the hot-water boiler would have be reduced gradually and, although the water in the boil has considerable storage capacity for heat absorption, is all sensible heat and the surplus has to pass into th heating system when not needed, or with no steam spa the pressure will go up rapidly. It is a common occu rence to have a change of from 25 to 50 deg. in outsi temperature during a week and this change sometimes o curs in a few hours. When the outside temperature rang from 10 to 20 deg. the requirements are 80 per cent. the maximum heating load at zero. At 40 to 50 de outside temperature the load would be 36 per cent. of t maximum, or less than 50 per cent. of the former r quirement. In hot-water boilers the fires would have be withdrawn and rebuilt or banked for a period of hou to perhaps days, as the requirements demanded. As t peak heating load only occurs from 2 to 6 per cent. the short period even at the cost of more fuel.

With a live-steam heater efficiently covered and a seal steam circuit, there would be practically no loss exce by radiation and such a heater for, say, 60,000 sq.ft. heating surface can be installed and connected for le than $1000. By its use there would be fewer fires take care of and less banking in the periods between pe loads. Of course, if the steam boilers were old and wea ened, so as to be unfit for high pressure, it would n make any great difference whether they were placed in t water circuit directly or not.

Editorials

Utilizing a Great Natural Resource

Long as it has been known that there is power in falling water, it has remained for the present decade to show serious disposition to utilize any appreciable part of this great natural resource. Scientists and students of the situation have repeatedly warned us of the ultimate exhaustion of our fuel supplies, only to be accounted as alarmists by some, while others, almost as heedless, have dismissed thought of the consequence of such a prospect, evidently misapplying the biblical admonition, "Sufficient unto the day is the evil thereof." Rather selfishly, it would seem, they would leave it to coming generations to worry about, justifying themselves with the prediction that, when the time comes, some substitute for coal will be found. While this may be true and there are already evidences that water will be one of the important factors in meeting the conditions, it does not relieve the present generation of its responsibility.

Beginning with a few, a steadily growing number have sensed the gravity of the combination of an ever-increasing population (and they becoming more and more demanding in the gratification of their desires for comfort and even luxuries, thus stimulating the affected industries) and a constantly diminishing store of the yet unused minerals and other raw materials. Thus has been born the Conservation Movement, at first regarded as little more than a fad, but today recognized as a worthy work and so rapidly extending its influence that no one can estimate its future importance. It is not confined to the conservation of fuels but includes more particularly at present the preservation of the forests and others of the supplies drawn from nature, the depletion of which is most threatening.

Consciously, or otherwise, the engineer has always been naturally a conservator, for, next to finding ways of doing new things, it has been his function to find new ways of doing old things more efficiently, which means at less expense. Although his motive has been reduction of cost per unit of production, he has, nevertheless, served significantly in minimizing the waste for which those yet unborn would the sooner have suffered.

To offset the engineer's endeavors, however, there has been the human tendency to greater prodigality in the use of everything that is made cheaper. As fast, for example, as means of transportation have been improved in economy, greater demands have been made upon them, as for greater speed, added comfort or their more extended use. So it is a question if, after all, the work of the engineer has not had the effect of accelerating the exhaustion of many of our resources.

Conservation of the supply of woods seems in a fair way to be solved. The government is active in the cause, directing attention to the need of conserving and the means of so doing. The forests are striving to replace themselves and are being assisted by cultivation and by precautions against their destruction by fire. When consumption gets ahead of growth, advancing prices discourage waste and even many uses so that metal substitutes are found, and the attractiveness of profits in the field of forestry draws more into the ranks. More or less automatically, therefore, forest preservation takes care of itself.

But what shall be done for heat, light and power when coal, gas and oil are gone? From seed to cut timber is a matter of a few years, but our mineral resources were ages in the forming. The next most evident step, then, and the time to take it is now, that the fuels may last the longer, is the utilization of water powers. Although more has been done recently than ever before, it is as nothing to what may be done before any considerable part of the immense available supply of energy from this source is in service.

What a contrast is afforded between the small beginnings in New England a century or so ago when that was the only industrial center of this country, and the plants in the Middle and Far West and the South which have lately been put into commission. Compare the old undershot and overshot wheels of that earlier time which got such a small part of the energy out of the falls, with the present highly efficient hydraulic turbines. Then, use of the power was restricted to within distances reachable by belt or rope transmission. Today, by electric current, the power is being distributed over hundreds of miles.

As boys we stood down by the old sawmill and watched the water pour over its clumsy wheel and it was all very wonderful to us. Now, older and less impressionable, we are still more thrilled when we stand in a plant such as those at Keokuk, Hale's Bar or Tallulah Falls, described on another page of this issue, and hear the hum of the mighty machinery or gaze over the construction work that brings this power to the generators. Truly we can but marvel when we think of what has been done and conjecture what may be.

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The Cinder-Catching Problem

The evolution of cinder-catcher apparatus, as carried out at the Waterside stations of the New York Edison Co., will be described in Power in a series of articles, the first of which appears in this issue. Engineers acquainted with modern boiler and metallurgical-furnace practice know that much has been accomplished in recent years in abating smoke from such furnaces, but that little has been done in contriving an apparatus to successfully catch the cinder.

There will also be described for the first time, and often in detail, numerous cinder-catching schemes, many of which, although not suitable for the Waterside stations, should prove valuable in smaller plants where the conditions are less extreme. These devices should also be helpful to engineers confronted with the cinder nuisance in central stations, in cement and even in factory plants in thickly settled districts or near parks, where vegetation is destroyed. Smoke-inspection departments should find many valuable suggestions applicable to their work.

It is gratifying to know that with baffles and piping of suitable material, the water in the cinder-catchers may be used over and over, although much make-up water is needed to replace that lost by evaporation and in spray carried away by the gases. To avoid unduly rapid deterioration of the metals it would be better to draw off the water and suppy fresh water more often rather than continue its use until it became heavily impregnated with the sulphurous and sulphuric acids. This, of course, would depend on the cost of pumping, whether the plant was close to a river or other water source, and to the price of water if purchased from the city. Probably there are cities which would sell water at reduced rates for cinder-arrester purposes that they might rid themselves of the nuisance as it now exists.

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Public-Utility Securities

One of the favorite arguments of the water-power interests against government charges for water privileges is the high initial investment necessary and the financial risk involved. That the first cost is usually high is undeniable, but in the light of recent statistics the risk appears more fanciful than real.

The particular statistics to which we refer were compiled by Henry L. Doherty & Co., a well known firm of bankers and extensive dealers in public-utility securities. The statistics cover a period of ten years and by means of charts show clearly the comparative increase in outstanding securities of gas and electric, steam railroad and industrial companies, also the net earnings in each class. In spite of an increase in railroad securities of 54 per cent. during this period, the rate of net earnings has remained fairly constant, averaging about 4.25 per cent. The increase in industrial securities was less than 20 per cent. and the net earnings averaged 7.79 per cent., although with violent fluctuations. In striking contrast has been the increase in gas and electric securities, of 110 per cent., with an average net return of 8½ per cent. Moreover, this rate has been particularly constant.

Of still greater significance in showing the stability of public-utility securities is the fact that the average annual amounts of securities in receivers' hands per $100 of outstanding securities for the past 30 years has been as follows: Gas and electric companies, 37 cents; national banks, $1.93; railroads, $1.84, and industrial establishments, $2.07. These figures include all gas and electric companies and steam railroads in the United States and all industrial concerns large enough to have been mentioned in financial reports. Just what proportion of these electrical securities represent water-power developments and what proportion steam plants, is not stated, nor is it shown how the average return on steam plants compares with that on water-power plants; such a comparison would be most instructive. Government reports, however, for this period, show that water-power development increased by nearly 200 per cent., which is even greater than the combined utilities. Hence, it may be assumed that the net earnings as stated fairly represent those on water-power developments, and that instead of representing a risk they are actually safe and attractive investments.

Safety Valves on Superheaters

A correspondent calls attention on page 132 to an interesting situation. A rule formulated by the Massachusetts Board of Boiler Rules and adopted by the Ohi Board prescribes that: "When a superheater can be shut off from a boiler, whether attached or separately fired, it shall have an ample safety valve *at or near the steam inlet.*"

If the only purpose of the valve were to relieve th superheater from an accumulation of pressure when i was shut off from the boiler, it would not seem to mak much difference whether it were located at the inlet o the outlet of the superheater. The motive in setting th valve at the inlet was apparently to save it from the effects of the superheated steam; but when the superheate is shut off from the boiler, which it would be in this case by a valve between the safety valve and the boiler, al that it could discharge would be very highly superheate steam, although there would not be much of it, and th valve might as well be located at the outlet or the middl of the superheater.

A safety valve located at the outlet of the superheater however, and set a few pounds lower than the safety valv on the boiler itself, serves another useful purpose whic justifies its use even when the superheater cannot be shu off from the boiler and is guarded against overpressur by the main safety valve. In case of a sudden and seriou diminution of the call for steam the boiler will reliev itself through the superheater, keeping it from burnin out while the fires are being brought under control. But a safety valve so located does not comply with the law There is nothing to prevent the use of two, one to sav the superheater and the other to satisfy the inspector, bu it would be interesting to know why that upon the outlet would not serve every purpose of safety in the case o a superheater which "can be shut off from a boiler" besides furnishing a precaution against the injury of th superheater when it is not so shut off.

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The Babcock & Wilcox boilers at one of the stations o the Boston Elevated Railway Co. are set eight feet abov the stoker grate, at the rear or lowest end. It is interesting to know that should more boilers be installed this distance may be increased, but surely never diminishe From all indications, we may expect to see an extensiv application of the scheme of raising boilers much highe above the grate than has heretofore been practiced.

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The announcement that the engineering department of Harvard University and the Massachusetts Institut of Technology are to merge, may be regarded as one o the most important educational steps of recent years. Th already splendid organization of the Institute, with it recent acquisition of funds for new buildings and equipment, augmented by the liberal endowment of Harvard should make it possible to set a new standard for eng neering instruction and at the same time take up researc work on an extensive scale, as is being done by some o the European universities.

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We are glad to see that the daily press has at last take up the question of electricity rates in New York Cit This should be a potent factor in arousing the interest o those most concerned.

Correspondence

Excess Air and CO_2

H. L. H. Smith's article on the above subject, in the Nov. 25 issue, was read with a mingled feeling of sympathy and amusement. Someone has evidently been bombarding Mr. Smith with "excess air," so long ("six or eight years") and so persistently that it got on his nerves. This excess of "excess air" and CO_2 argument with which Mr. Smith has been so "continually afflicted and pastered with" must have been local and possibly personal. The technical press certainly has not given this question undue consideration, since the majority of operating engineers still seem to lack a clear understanding of what is necessary to *attain* and *maintain* maximum boiler efficiency.

Mr. Smith asks: "Why do we speak of excess air at all, why not substitute deficiency of coal?" There are several reasons why it is more logical to speak of excess of air than of deficiency of coal.

1. Because the first is definite and the second is indefinite. For any given fuel, a definite per cent. of CO_2 means a definite per cent. of excess air. If the fuel were pure carbon, the excess of air would be as follows: For 70 per cent. CO_2 200 per cent., 10½ per cent. CO_2 100 per cent., 14 per cent. CO_2 50 per cent. excess. This relation is also very nearly correct for anthracite coal, but the excess of air for a given per cent. of CO_2 becomes less as the content of hydrogen in the fuel increases, but the relation is always a definite one. Furthermore, every per cent. of excess of air carries to waste up the chimney a definite amount of heat for every pound of coal consumed. On the other hand, what relation is there between CO_2 and deficiency of coal on the grate? For example, what per cent., how many pounds or shovels full of coal deficiency does 7 per cent. of CO_2 represent? The idea is absurd and really does not matter, but what does matter is Mr. Smith's remedy. He says: "If the CO_2 is thought undesirably low, and the draft is fixed, let the fireman shovel coal more rapidly." This will, no doubt, increase the rate of driving and may result in a higher per cent. of CO_2 but it by no means follows that it will be conducive to fuel economy, because:

2. The low CO_2 (excess air) may be due to other causes than a thin fire (deficiency of coal). There may be ample coal on the grate, but if it is not evenly spread, low CO_2 will result; in which case shoveling coal more rapidly will only aggravate the waste because of a deficiency of air through part of the fuel bed, resulting in incomplete combustion. What is needed is not more rapid shoveling of coal but more careful and skillful firing.

3. All the excess of air does not come through grates. From 50 to 100 per cent. or more may come in through cracks in the setting, loose door frames and warped cleaning door, and by infiltration through the pores of the brick.

Air entering beyond the fire does not aid combustion and is just as damaging to economy as though it came through the fire. Under these conditions, which are most likely to be found where the accelerated coal-shoveling idea prevails, if the per cent. of CO_2 is forced up by thickening the fire, the beneficial effect obtained from the increased CO_2 may be fully neutralized by incomplete combustion, due to deficiency of air through the fire.

Mr. Smith's statement that "in general the rate of steaming follows the rate of shoveling" is true, but there is a vast difference between shoveling coal and economical firing, and the proposition to bring up the per cent. of CO_2 by merely increasing the speed of the shovel is entirely wrong.

The first step to increase the per cent. of CO_2 is to stop all the air leaks beyond the furnace. The second is to maintain an even fire of the proper thickness, by regular, skillful and careful firing. The third is to regulate the air supply so as to produce the highest per cent. of CO_2 compatible with complete combustion. The speed of the shovel must always keep pace with the demand for steam. If these conditions are fulfilled, it will not have to be accelerated merely to increase the per cent. of CO_2, and high CO_2 will spell high efficiency.

E. A. UEHLING.

Passaic, N. J.

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Accident as Evidence of Negligence

There is a rule of law applicable to personal injury cases that when an instrumentality which caused the accident without fault of the injured person is shown to have been under the exclusive control of the defendant, and that the injury is such as in the ordinary course of things does not occur if the one having such control uses proper care, it affords reasonable evidence, in the absence of an explanation, that the injury arose from the defendant's actionable negligence.

In the case of Hill vs. the Pacific Gas & Electric Co., 136 "Pacific Reporter" 492, which was recently before the California District Court of Appeal, it appeared that the defendant power company supplied electricity to a mining company through a wire carrying 4400 volts, and that an employee of the latter company was electrocuted while attempting to switch power to a pump. The plaintiff, in suing to recover damage on account of the accident, attempted to invoke the rule above stated, but the court decided that it was not applicable to the power company—that an electric power company is under no obligations to examine and inspect the fixtures and appliances used by its customers and under their control. The court found that the power company's control ended at the meter, and said in part: "Plaintiff's contention is that, because of the extremely dangerous character of this element brought into use by these electric power companies, they should be compelled not only to superintend the installation of all appliances constructed to receive and utilize this dangerous element, but should be charged with such inspections from time to time of all such appliances as would relieve the power companies from the charge of want of care and would enable them at all times to explain that any accident which might happen through its use was not the result of want of care on their part. When we consider the multitudinous uses to which electricity is now being applied, and assuming that the user receives it by means of appliances of his own choice, erected by himself, and under his control and management, as in the present case, it would be an intolerable burden to require of the power companies what is here contended for."

It was further held by the court that it was open to the jury to find, under the rule referred to, that the mining company was guilty of negligence. Therefore the plaintiff not only joined the power company and the mining company as defendants, but also included the president of the company and the electrician who installed the appliances. The court, finding that the president employed a competent electrician and that the mode of installation was not negligent, exonerated both of them. Hence, judgment against the plaintiff, awarded by the trial court, was affirmed as to the power company and the individual defendants and was reversed as to the mining company, a new trial being awarded against that company.

A. L. H. Street.

St. Paul, Minn.

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Old Motor Drives Improvised Emery Wheel

It was found necessary to use an emery wheel quite often during the day, and the company did not choose to get one for the power house. The machine shop was quite a distance from the power house and much time was spent in going to and from the shop whenever it was necessary to use the emery wheel. I then began to look around for something to make one of.

In the electrical department I found four 15-hp. Edison bi-polar shunt-wound motors of an old type that had been replaced with better machines. The armatures of these machines were of the hand-wound type, and the shafts and commutators were so badly worn that they were not worth repairing for use in the mill. Among the lot we found two field coils that were sound, and one armature that had only four coils cut out, and decided that this could be made to drive an emery wheel. The shaft extended past both bearings. One end of the shaft was turned down from 1¼ to 1 in., and threaded with a right-hand thread. Also two collars were turned out, one to fit against the shoulder and the other against the emery wheel.

The other end of the shaft was arranged to carry a grinding disk for polishing the nuts and caps of the water-tube boilers. The end of the shaft was turned down to ¾ in., and threaded with a left-hand thread. The grinding disks were made ½ in. thick by 8 in. in diameter and tapped to fit the stud on the end of the shaft, and were finished with a rough cut. Round pieces of emery paper of the proper grade were glued on each side of these disks, the rough surface helping to hold the paper. We had several of these disks made and covered. The old paper when worn out was removed by placing the plate in hot water.

The machine was bolted against the wall in the boiler room, and a rest made to steady the work when using the emery wheel. The original speed of the motor was 1300 r.p.m., but with four coils cut out it ran somewhat faster than this.

J. C. Hawkins.

Hyattsville, Md.

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Kerosene Carburetor

In the Jan. 6 issue an article by J. A. Lucas appears entitled, "A Unique Kerosene Carbureter," describing a process produced by Alexander E. Porter, 171 Broadway, New York.

From reading the article it would appear that Mr. Porter had invented and developed this process, yet if Mr. Lucas had thoroughly investigated this matter he would have found that the patent covering this process was in the names of Alexander T. Porter and Herbert E. Rider, dated June 10, 1913, and that by some mistake in the United States Patent Office this patent was issued when an application for letters patent by Granville S. Rider covering the same process was pending, having been filed some three months previous to the Porter-Rider application for a patent.

However, this patent has been put in interference with the G. S. Rider application and is now before the United States Patent Office for adjudication.

E. M. Engelman, President,
Rider Gasifier Co.

New York City.

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Location of Safety Valves on Superheaters

An engineer friend has put a question of law to me that I am unable to answer; possibly some of the readers of Power may be interested and able to offer some helpful suggestions. My friend has two boilers that are equipped with superheaters. The superheaters were provided with safety valves as advised by the superheater manufacturers, and these valves were located directly on the outlet pipes from the superheaters. A boiler inspector came along some time ago and told my friend that he did not have his boilers equipped according to law, and referred him to a rule given on page 60* of the Ohio Boiler Rules, which reads as follows:

> When a superheater can be shut off from a boiler, whether attached or separately fired, it shall have an ample safety valve at or near the steam inlet.

My friend and the inspector had a long argument about why the steam could not be released equally well from either end or the middle of a superheater, with the inspector on the losing side, when suddenly the inspector brightened up and said that they were both chumps, for, of course, the safety valve was required to be placed on the inlet pipe to protect the valve from the superheated steam. This argument completely captivated my friend, the engineer, and he thanked the inspector and proceeded to relocate the valves as required.

Recently, my friend took a trip to Chicago, and naturally visited some of the big power plants. At one plant he found superheaters attached to the boilers without any top valves between them and the superheaters but all provided with safety valves on the outlets from the superheaters. He felt a little leery about pointing out defects to the engineer who was showing him around but finally overcame his timidity and told the engineer that he wished to show him an error in the equipment that was provided against by the Ohio Rules, and proceeded to enlighten him on the proper location of safety valves for superheaters. The Chicago engineer listened attentively until my friend had finished and then had a long hearty laugh. He told my friend that it had cost his company several thousand dollars to learn that superheaters should always have safety valves placed on the outlet pipe, and that such valves must be always set a few pounds below the popping point of the valves on the boilers, so that the superheater valves would be certain to act first. The engineer explained that unless this was the case a sudden throwing off of the load on the plant would stop the flow of steam through the superheater, and without this flow the superheaters were liable to be overheated and ruined, before the fires could be checked. He said that several accidents of this kind, where the valves on the superheaters were set at too high a pressure, had caused a big expense to his company, on account of "fried superheaters" as he expressed it. The Chicago engineer said that if the Ohio Boiler Rules were made to protect the safety valve, they should have specified the outside-spring type of valve for such use, and he also stated that these valves should have been specified properly located and set, to prevent injury to the superheater, which he claimed was the real purpose of safety valves for superheaters.

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*Page 90, Ohio Rules, Edition of September, 1913; page 48, Massachusetts Rules, Edition of September, 1911.

My friend is now thoroughly convinced that the Chicago engineer knows more about the matter than the makers of the rules, and is between the devil and the deep blue sea; he cannot change his valves without violating the law and he lives in mortal dread of a sudden break down in the plant presenting him with a couple of "fried superheaters." What he would like to know is, can his company collect damages from the state of Ohio in case his superheaters are ruined by complying with the law. I have passed the question up. I understand that this rule was copied from the Massachusetts rules and that such a rule is still in force in that state; if so, the question of my friend may be of interest to engineers in the state of Massachusetts.

J. K. LINDERHURST.

Toledo, Ohio.

⁂

Locating Grounds on Transformer Secondaries

Until recently, a certain central station had considerable trouble in locating grounds on the secondaries of lighting transformers supplying a number of consumers. Most of the grounds, while in themselves not serious, caused a drop in voltage, resulting in complaints about poor lights. An inspection of the wiring on the premises of each consumer was then necessary in order to locate the fault which was generally found in the lamp fixture.

As this inspection consumed much time, a scheme was devised which made use of a 220-volt recording voltmeter connected between the ground and the ungrounded leg of the three-wire service. All that then remained for the inspector to do was to visit each house which received service from the grounded transformer, pull out the main switch for an instant and note the exact time at which the observation was made.

By consulting the chart obtained from the recording voltmeter and comparing the time at which a drop in voltage occurred with the record of time taken while on the premises of different consumers, the house containing the faulty wiring could be located, for upon opening the switch feeding the ground a drop in voltage would have occurred. This scheme worked successfully on circuits having one or more grounds, since upon the removal of any one, a drop in voltage resulted. Upon removal of all the grounds normal voltage (110 volts) would be recorded. The voltmeter can be connected at any point on the transformer secondary.

F. H. OBERSCHMIDT.

Cincinnati, Ohio.

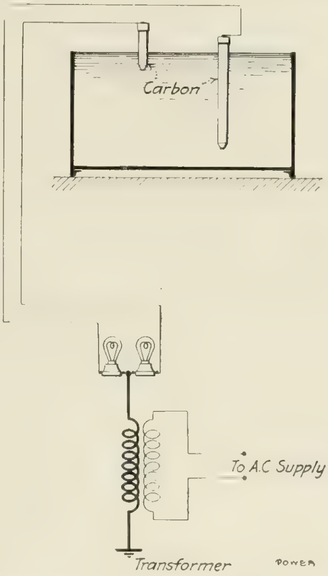
⁂

Another Electric Water-Level Indicator

Water for our barometric condenser is supplied from a cooling tower above the condenser and above the engine-room roof; consequently some means for determining the water level in the pan under the tower was desirable. The pan is shallow, it being only 5 in. from the bottom of the pan to the overflow.

A float was found to be impracticable so the following arrangement was made.

A 200-watt transformer was connected as shown in the sketch. One side of the transformer was grounded and the other side was connected through a pair of lamps in multiple to the water level in the pan. The terminals were a pair of arc-lamp carbons. One was adjusted to make contact with the water just before the pan went dry. A red light indicated overflow, a white light safe water level and no light, no water, and that it was time for the attendants to get busy.



CONTINUOUS WATER-LEVEL INDICATOR

THOMAS G. THURSTON.

Chicago, Ill.

Safety-Valve Action Discussed

Relative to the safety valve problem for discussion in the issue of Nov. 18, page 729, I beg to offer the following: The writer of the letter, Mr. Hastings, failed to state what size valve it was that raised $\frac{1}{16}$ in. from the seat and then quickly opened wide. It is rarely that the mechanism of any valve will allow of a lift of more than $\frac{1}{8}$ in. per inch of seat opening, i.e., a 1 in. valve could not lift more than $\frac{1}{8}$ in. probably, or a 2 in. more than ¼ in. without the lever or some other part of the mechanism striking a stop. This stop is provided not so much as a precaution against the valves blowing wide open in ordinary operation, as this is very unlikely as further explanation will show, but in case the weight should be misplaced on the lever or moved by accident from its proper location it prevents the lever from lifting so high as to cause the weight to slide back on the same and so, of course, prevent the valve from closing until the pressure is greatly reduced.

The conditions stated by Mr. Hastings in the last sentence of the first paragraph of his letter are contrary to my experience with this type of valve and are also contrary to reasonable deduction from the conditions of operation. Mr. Hastings neglects to state whether, after the pressure had been allowed to accumulate to 2 or 3 lb. above the setting, and the lever then released, he maintained the pressure under the disk at this point or allowed the valve to reduce the pressure.

In experiments with which the writer is familiar even if the pressure under the disk were maintained considerably above the setting by supplying a larger quantity of steam than the valve was suited to discharge the disk still lifted not more than $\frac{1}{32}$ to $\frac{1}{16}$ in. for, say, a 1½-in. valve and only slightly more for a larger-sized valve. The reason appears very apparent, for, as the writer states, the velocity head of the issuing steam would be twice far enough above the seat to enable this head to act on it. In fact, the direction of flow of the issuing stream is not upward but is chiefly across the under-surface of the disk from the center outward toward the circumference and only at a slight upward angle and so there is only a small component of this velocity head which may be considered as adding to the pressure head to help it lift the disk.

Obviously the greater the lift the greater this component, but I should judge that the disk would have to lift at least as far away from the seat as the diameter of the opening to get the full effect while if it lifts one quarter of this amount the full area of the seat is provided for discharge of the steam. A further fact which prevents even this small component from adding directly to the pressure head is that the pressure is constantly decreasing under normal conditions, due to the discharge, so that the pressure head will be less after the valve opens than that which the weight is set to balance. In operation, in an extreme condition, there is no reason why the disk should open more than an amount equal to one-quarter of the diameter of the seat. This gives full area on the basis of a flat seat, and as soon as the valve opens the pressure immediately reduces under the disk to an amount less than that at which the steam started to discharge, because the connecting pipe, even though short, cannot maintain the pressure and the disk is held up by the pressure plus the component of the velocity head until this sum reduces to less than the setting when the disk closes. It would be foolish to state that it would be impossible to blow a valve of this type wide open if the mechanism would allow it. The only conditions under which it would be done would be in case the pressure continued to increase after the valve opened or in case the valve stuck, so as to let a considerable overpressure accumulate before it opened, and no reputable manufacturer would furnish a valve with a mechanism that would allow this to happen.

Cincinnati, Ohio. E. G. Greenman.

⁂

Pipe Work and Fittings

In the issue of Dec. 9, a correspondent comments on the carelessness of engineers in running pipe lines and on the use of unnecessary fittings. He also laments the general ignorance of so called engineers and their lack of ability. If Jones at the sawmill packs his piston rods with a cotton clothesline, soaked in tallow, that is his affair. His boiler only carries 60 lb. steam pressure, and if the packing does leak, he has plenty of water and sawdust fuel, and blowing steam may be music to his ears.

Getting back to engineers in general, how many know that pipe lengths over 12 in. in diameter are measured on the outside? That but five standard thread sizes are used for all sizes of pipe from the smallest to the 12-in.? That large pipe lengths are not made for threading when ¼ in. thick or less, as the threads would cut too deep.

Valves have leaked when connected up because strains in the pipe line have warped the valve seat, or because a wrench was used on the wrong end of the valve when it was screwed in place. Always use the wrench on the end of the valve being screwed on the pipe. When running large pipe, each length should be supported independently of the rest of the line and rest on roller brackets.

The weight of a pipe line should never be carried by a valve in the line, as a large valve seat may be warped by the strain; always have the pipes in line before bolting together. Neglect of this will cause leaky joints when the strain of holding the pipe in line comes on the bolts, gaskets and flanges.

When several engines take steam from a common steam line, a certain load on the engines will often cause vibration. This can be overcome by suitably bracing the pipe line, taking care that the braces do not interfere with the piping, thus causing serious strains on some part of the system. It is better to brace a pipe near the boiler.

Mr. Purcell, in the Dec. 16 issue, makes a suggestion for priming a condenser circulating pump, but does not state if a surface or jet condenser is meant. He evidently refers to a surface condenser, as the circulating pump of a jet condenser is acted on by the vacuum and his device would not be necessary.

His scheme will work, but if his proposed pipe from the circulating-pump casing to the dry-vacuum pump were tapped in the circulating-water line, between the circulating pump and condenser, and the other end tapped into the condenser proper, the water would come high enough in the suction line for the pump to pick it up and force it through the condenser. There would then be no danger of getting water in the dry-vacuum pump, as any water brought over through the priming pipe would go to the condenser and be carried off with the water of condensation.

Philipsburg, Penn. J. H. Hoffman.

Inquiries of General Interest

Density of Steam—What is meant by the density of steam?

H. T.

Density of a substance is the relation of its weight to its bulk or volume, and in steam engineering the density of steam is usually quoted as weight in pounds per cubic foot.

Distinguishing the Positive from the Negative Electrode—By immersing a positive and a negative electrode in a salammoniac solution, which will give off the greater number of bubbles?

G. K.

The negative electrode.

Removing Burnt Cylinder Oil from Bright Surfaces—How can a deposit and discoloration due to burnt cylinder oil be removed from finished metallic surfaces?

J. T. H.

Any gummy hydrocarbon can be removed with gasoline; if a noninflammable application is to be preferred, use carbon tetrachloride. The solid carbonaceous matter has to be removed by scraping, or by burning with a jet of oxygen gas Discoloration would have to be removed by refinishing.

Pressure and Velocity—Why does it require four times the pressure to double the velocity of flow of steam?

J. W. D.

The velocity of flow of a fluid is as the square root of the pressure. It is a fundamental law of nature. Water, for instance, issues with the same velocity from the center of an aperture in the side of a reservoir as the velocity which would be attained by a body falling through a height equal to the distance from the surface of the water to the center of the aperture and it is known by observation that such velocity is as the square root of the height, hence it requires four times the height or pressure to double the velocity.

Relative Sizes of Pump-Suction and Discharge Lines—Why is a pump-suction line generally made larger than the discharge line?

E. M.

For a given discharge per minute loss of pressure in a pipe line decreases with increase in the size of the pipe. The loss of head due to friction in a discharge line may be overcome by applying sufficient power to the pump, but with a given supply, the loss of head in a suction pipe can usually be overcome only by increasing the size of the pipe. Under most conditions, it is practicable to provide a suction line of larger size of pipe than that of the discharge line.

Hammering in Suction Pipe—How can the hammering noise in a pump suction pipe be prevented where the water is supplied under pressure?

M. B.

The hammering is due to sudden checking of the velocity of the water in the pipe and can be reduced by increasing the size of the supply pipe, or by providing an air chamber on the suction pipe near the pump. Such an air chamber for a single-cylinder pump should have a volume of about six times the displacement of one stroke of the pump and for duplex pumps about four times the displacement of one stroke of one water cylinder. The air chamber may be of usual form, or made of a large size of iron pipe.

Horsepower of Alternators—What is the formula for finding the horsepower of two alternators in parallel from the voltmeter and ammeter when there is no wattmeter?

T. P. M.

It is not stated whether the switchboard is equipped with a power-factor meter; but assuming that it is not, and that there is a motor load, let the power factor be 80 per cent. Then Horsepower =

$$\frac{\text{Amp. per phase} \times \text{voltage (across any two leads)} \times 1.73 \times 0.85}{746}$$

This assumes that the load is balanced and the ammeter reading is taken on the line side of the busbars; if the ammeters are on the individual machines the readings will have to be added.

Absolute Pressures—What is meant by absolute back pressure and absolute terminal pressure, and what is the difference between both?

E. P.

"Absolute pressure" of any kind means pressure above vacuo and is called "absolute" because in common language pressure generally means gage pressure or boiler pressure, which is pressure above atmospheric pressure. Absolute back pressure, therefore, means the total pressure worked against by the piston including atmospheric pressure and is the back pressure ordinarily referred to, plus atmospheric pressure. Absolute terminal pressure means the pressure in a steam cylinder above vacuum, when the piston is at the end of the stroke and usually refers to the final pressure of expansion after cutoff has taken place and at the instant of release.

Computing Power of Compound Engine—Employing a single horsepower constant, what is the method of computing the horsepower of a 12x24x30-in. compound engine running 106 r.p.m., the mean effective pressure of the high-pressure cylinder being 60 lb. and that of the low pressure being 14 lb. per sq.in.?

J. H. C.

The mean effective pressure of both cylinders may be referred to either cylinder and the computation may be based on the horsepower constant of the cylinder referred to, but it is customary to refer to the low-pressure cylinder. The diameters of the cylinders being respectively 12 and 24 in., and the stroke of both pistons being 30 in., the ratio of the piston areas and of the cylinders is as 1 to 4.

Each pound mean effective pressure of the high-pressure cylinder will therefore be equivalent to ¼ lb. mean effective pressure of the low-pressure cylinder.

The low-pressure cylinder being of 24-in. diameter, the area of the low-pressure piston is 452.39 sq.in. and the horsepower constant for the low-pressure cylinder is

$$\frac{30 \times 452.39 \times 106 \times 2}{12 \times 33{,}000} = 7.265 \text{ hp.}$$

Referring the mean effective pressure of both cylinders to the low-pressure cylinder, their combined mean effective pressure referred to that cylinder would be equivalent to

$$\frac{60}{4} + 14 = 29 \text{ lb. mean effective pressure}$$

and the horsepower would be

$$7.265 \times 29 \quad 210.68 \text{ hp.}$$

Position for Ball on Safety-Valve Lever—At what horizontal distance from the fulcrum should the 130-lb. ball of a 3-in. lever safety valve be placed so that the valve will blow off for a boiler pressure of 90 lb., the weight of the valve being 12 lb., its distance from the fulcrum of the lever to the center of the valve being 8 in., and the lever weighing 40 lb. when supported at 20 in. from the fulcrum?

B. C. H.

The valve being 3 in. in diameter its area would be

$$3 \times 3 \times 0.7854 \quad 7.0686 \text{ sq.in.}$$

and the total pressure of steam tending to raise the valve would be $7.0686 \times 90 = 636.174$ lb.

The pressure on the valve due to the weight of the lever would be $\frac{20}{8} \times 40 = 100$ lb.,

and the weight of the valve being 12 lb., the downward pressure exerted by the lever and the valve would be

$$100 + 12 \text{ or } 112 \text{ lb.}$$

Therefore, neglecting friction, the net upward pressure to be resisted by the leverage of the ball would be

$$636.174 - 112 = 524.174 \text{ lb.}$$

The distance of the valve from the fulcrum being 8 in., the upward movement or leverage of steam pressure acting on the valve, which must be equaled to be balanced by the downward leverage of the ball, would be

$$8 \text{ in.} \times 524.174 \text{ lb.} = 4193.392 \text{ in.-lb., hence}$$

a ball weighing 130 lb. would have to be so placed that its center of gravity would be

$$\frac{4193.392 \text{ in.-lb.}}{130 \text{ lb.}} = 32.254 \text{ in.}$$

or practically at 32¼ in. from the fulcrum, for the valve to blow off when the boiler pressure becomes 90 lb.

Engineers' Study Course

Trigonometry—X

Last Lesson's Answers

41. Two sides (a = 847, b = 579.4) and the included angle (C = 36 deg.) are given (a Case III problem). Using the first method at the end of the last lesson:

$$tan\ \tfrac{1}{2}\ (A - B) = \frac{847 - 579.4}{847 + 579.4} \times tan\ \tfrac{1}{2}\ (180 - 36)\ deg.$$

$$= \frac{267.6}{1126.4} \times tan\ 72\ deg. = \frac{267.6 \times 3.0777}{1126.4} = 0.5774$$

Therefore ½ (A − B) = 30 deg.

Since

$$A = \tfrac{1}{2}\ (A + B) + \tfrac{1}{2}\ (A - B)$$
$$A = 72 + 30 = 102\ deg.$$

and since

$$B = \tfrac{1}{2}\ (A + B) - \tfrac{1}{2}\ (A - B)$$
$$B = 72 - 30 = 42\ deg.$$

Check: (A + B + C = 180 deg.)

$$102 + 42 + 36 = 180\ deg.$$

Side c is found from the equation $\frac{a}{c} = \frac{sin\ A}{sin\ C}$

$$\frac{847}{c} = \frac{0.9781}{0.5878} \qquad c = \frac{847 \times 0.5878}{0.9781} = 504.37$$

42. Given b = 527.8, c = 723.6 and A = 100 deg.

This, also a Case III problem, will be solved by the second method given in the last lesson, finding first the missing side from equation 28:

$$a = \sqrt{\left((527.8)^2 + (723.6)^2 - [2 \times 527.8 \times 723.6 \times (-0.1736)]\right)}$$

$$a = \sqrt{278{,}572.84 + 523{,}596.96 + 132{,}601.26}$$

$$= \sqrt{934{,}771.84} = 966.8$$

(Note that C being an angle of the second quadrant, its cosine is negative. See Table II, Lesson II).

From equation 27,

$$\frac{966.8}{527.8} = \frac{0.9848}{sin\ B} \qquad sin\ B = \frac{527.8 \times 0.9848}{966.8} = 0.6352$$

Therefore angle B = 32½ deg., closely.

From equation $\frac{a}{c} = \frac{sin\ A}{sin\ C}$,

$$\frac{966.8}{723.6} = \frac{0.9848}{sin\ C} \qquad sin\ C = \frac{723.6 \times 0.9848}{966.8} = 0.7388$$

Therefore angle C = 47½ deg., closely.

43. Given a = 60 ft., b = 60 ft., and C = 110 deg.; required the side c.

This can be found directly from the equation

$$c = \sqrt{a^2 + b^2 - 2\,ab\ cos\ C}$$

$$c = \sqrt{(60 \times 60) + (60 \times 60) - [2 \times 60 \times 60 \times (-0.342)]}$$

$$= \sqrt{9662.4} = 98.297\ ft.\ or\ about\ 98\ ft.\ 3\tfrac{1}{2}\ in.$$

44. Again, two sides (50 and 90 yd.) and the included angle (37 deg.) are given; required the third side.

From the same equation as in the last problem

$$c = \sqrt{(50 \times 50) + (90 \times 90) - (2 \times 50 \times 90 \times 0.7986)}$$

$$c = \sqrt{3457.6} = 58.8014\ yd.\ or\ about\ 58\ yd.\ 2\ ft.\ 5\ in.$$

45. This problem requires the solution of two triangles, first the triangle $ABCA$, Fig. 10, and then $BCDB$. The sides AB = 15 ft. and AC = 45 ft. and the included angle CAB = 84 deg. are given. Then, by the first method of solving:

$$tan\ \tfrac{1}{2}\ (\angle ABC - \angle ACB) = \frac{45 - 15}{45 + 15} \times tan\ \tfrac{1}{2}$$

$$(180 - 84)\ deg. = \tfrac{30}{60} \times tan\ 48\ deg. = \frac{30 \times 1.1106}{60} = 0.5553$$

Therefore ½ ∠ ABC − ∠ ACB = 29 deg., very nearly.

Since ½ (∠ ABC + ∠ ACB) = 48 deg.

$$\angle\ ABC = 48 + 29 = 77\ deg.$$

and

$$\angle\ ACB = 48 - 29 = 19\ deg.$$

Finding the third side, CB, by the Law of Sines:

$$\frac{CB}{45} = \frac{sin\ 84\ deg.}{sin\ 77\ deg.} = \frac{0.9945}{0.9744} \qquad CB = \frac{45 \times 0.9945}{0.9744} = 45.928$$

Since

$$\angle\ CBD = \angle\ ABD - \angle\ ABC$$

and

$$\angle\ ABD = \angle\ CAB = 84\ deg.$$
$$\angle\ CBD = 84 - 77 = 7\ deg.$$

Of the triangle $BCDB$ there are now known the side BC (45.923 ft.), the side DB (45 ft., being equal to AC) and the included angle CBD (7 deg.).

Solving by the second method to find the side CD directly,

$$CD = \sqrt{(45.923)^2 + (45)^2 - (2 \times 45.923 \times 45 \times 0.9925)}$$

$$CD = \sqrt{31.8} = 5.639\ or\ about\ 5\ ft.\ 7\tfrac{1}{2}\ in.$$

A short cut to the solution of the second triangle would have been to use the Law of Sines. The angle ABC was found to be 77 deg. and, CD and AB being parallel, the angle BCD equals ABC, hence is also 77 deg. This and the angle CBD and the side BD being known, it becomes a Case I problem, and

$$\frac{CD}{45} = \frac{sin\ CBD}{sin\ BCD} = \frac{sin\ 7\ deg.}{sin\ 77\ deg.} = \frac{0.1219}{0.9744}$$

$$CD = \frac{45 \times 0.1219}{0.9744} = 5.63$$

which is a check upon the answer already found.

When it is desired to be sure of the result of any solution of a Case III problem it is well to employ both the Law of Tangents and the Law of Cosines methods and see that the same answer is obtained with both.

Solution of Oblique Triangles Continued

Case IV

When the three sides of a triangle are given, the angles may be found directly from the equations expressing the

Law of Cosines. For example,

$$a^2 = b^2 + c^2 - 2\,bc\cos A$$

by transposition becomes,

$$\cos A = \frac{b^2 + c^2 - a^2}{2\,bc}$$

Similarly,

$$\cos B = \frac{a^2 + c^2 - b^2}{2\,ac} \qquad (31)$$

$$\cos C = \frac{a^2 + b^2 - c^2}{2\,ab}$$

When two angles have been found the third may be obtained by subtracting the sum of the other two from 180 deg., but usually it is safer to solve all three angles in the regular way and then see that the three total 180 deg. as a check on all of the calculations.

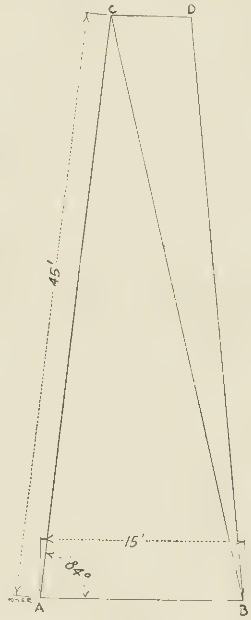


Fig. 10

There is likely to be some discrepancy when the three angles are totaled, especially if any of them involve fractions of degrees. This is because the differences between functions degree by degree are not equal and it is more or less of an approximation when degrees are split, to divide the functions proportionately, as with the use of a table, such as that in Lesson II. More complete tables reduce this error, but there is still apt to be a slight one when the three angles of a triangle are totaled, due to the calculations not being carried out to a sufficient number of decimal places. Unless, therefore, a material error is found in the 180-deg. total, it does not indicate any serious mistake in the calculations. Such difference as is found should be added or subtracted as the case may be, among the angles most likely to be in error. Generally in solutions by the Law of Cosines the bulk, if not all of the correction should be made to the smallest angle, for the cosines of angles near 0 deg. differ only slightly from one another, as may be seen from the table.

Areas of Triangles

The commonly known rule that the area of a triangle is equal to half the product of the base by the altitude generally is sufficient, but for the case of an oblique triangle of which the altitude is not known, although three or more of its parts may be, it becomes more convenient to use another rule which is:

The area of a triangle is equal to half the product of two sides and the sine of the included angle.

This may be proved as follows:

Referring to triangle $ABCA$, Figs. 11 or 12, by the familiar rule,

$$area = \tfrac{1}{2}\,c \times CD$$

But since $CD = a \sin B$ (Lesson VII),

$$area = \tfrac{1}{2}\,ac \sin B \qquad (32)$$

The area of a triangle can then be solved if three parts are given, for if these do not happen to be two sides and the included angle, the latter can be calculated from the known parts, as explained in this and the two previous lessons.

Study Questions

46. Given $a = 9$, $b = 12$ and $c = 15$; find the angles.

47. Given $a = 94.596$, $b = 104.653$ and $c = 100$; find A, B and C.

48. The only available site for a cooling pond is triangular in shape. The three sides measure respectively 100, 150 and 75 ft. What will be the angles at the corners of the pond?

49. Taking the above as the inside dimensions of the pond and that its depth is uniformly 5 ft., how much water will it contain?

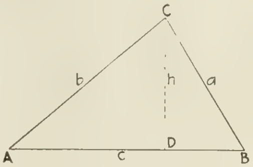


Fig. 11

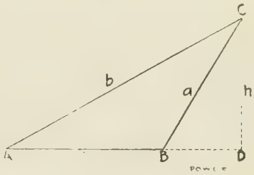


Fig. 12

50. A triangular guard is placed at one side of a rope drive which comes up through the floor. Its base is 6 ft., its altitude 8 ft. and one of the two inclined sides, which are parallel with the corresponding runs of the rope, is 8 ft. 6 in. What is the angle between the two runs of the rope?

⁂

Water-Power Control in West Virginia

Hydro-electric companies are at the present time deeply interested in the outcome of the conferences being held by the Public Service Commission to determine the plan under which the water development of West Virginia is to be carried on. Application for permission to erect dams are on file covering the Kanawha, New Gauley, Williams, Meadow, Elk, Buchannon, Cheat and West Fork Rivers. In some instances work has been started and near the Pennsylvania state line a mammoth dam on Cheat River has been partially completed.

The commission has prepared an outline of the form of permit it will present for discussion and unless material changes are made in it the regulation the commission would exercise over the hydro-electric companies would be the most complete ever attempted over any public-service corporation in West Virginia.

Every act of the hydro-electric companies from the purchase of the land, which would be submerged, would be subject to supervision, the commission would determine the capacity of the water plants and finally limit the net earnings of the companies, taking for the state 75 per cent. of the net earnings of the companies over 12 per cent. and placing it in a fund to be used ultimately for the purchase of the plants for the state.

⁂

Oil Refining Processes Improving—There has been unusual progress in many parts of the country during the past year in petroleum refining, especially in the dehydration of heavy crude oils, in obtaining gasoline from natural gas and synthetically from heavy oils.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Ford is 100 years ahead of his time," says Edison, referring to Mr. Ford's intention of distributing ten million dollars annually among his employees. Does Edison mean that it will be 100 years before any other concern does this little thing for us?

⁂

A big electrical manufacturing company sends us a story of "Faithful Service—Machinist Works 22 Years on One Machine." And remarks: "It is peculiarly refreshing to see one who has pursued the even tenor of his way undisturbed by the clamor about him." The life of the machine reflects credit on its maker, but we'd not say the same for this even-tenor teller. My gollies! think of putting in 22 years on a 2-in. turret lathe. No wonder he has an even tenor. Some ambition!

⁂

"Women shared in every important conference or movement in Great Britain the past year"—New York "World." Why, ever since that Eden episode they have been our wives, mothers and sisters (and other fellows' sisters). On this bright and sunny day we are even trying to think kindly of that lady typist who says her dictionary is always wrong—and spells accordingly.

⁂

By the way some folks nurse a grouch, you'd think that radium was its only cure, and that they were too poor to buy even a couple of pounds of remedy.

⁂

To those that go down to the sea in ships there has been added a new terror of the sea, the tango. Hitherto, our many trips to Europe have been for rest and recuperation. If we have to tango our way over in future, we'll quit—and go to Milwaukee in September.

⁂

Just one good word for an explosion. It occurred 439 ft. under a New York street and opened up the Catskill Aqueduct. The other side of the shield is that this tunnel has cost the lives of 283 men and injured 8833!

⁂

"Get out of one ton of coal the value of two!" Same old goldbrick, same old shell game. This time it's the "Fuel Economizer Mfg. Co." The "Economizer" prolongs the life of the fire at a "travial" cost and the powder is "dessolved" in water. Aha! Mister Sukker takes a 50-cent box. Who's next? E. Z. Mark takes one! If we really intended offering wholesome advice to this company, we'd employ the first two words of this paragraph. Get it?

⁂

The following letter explains itself—and "do not make no clinkers":

West Newton, Pa., Jan. 5--14.

W. S. Kuhn, the Elec. Co. of Pittsburgh, Pa.

Sir—Having seen the biggest mergers of electric co. I wish to draw your attention to a fuell saving device and labor saving. it is in the form of a simi circler bridge wall. when propley placed in by a expert. I guarnte to save 66% of fuell, and do not make no clinkers. makes perposanetley less smoke. and also burns all the smoke that is combustable. as a small quantity is uncombustable as it contains too much watery vapor and that cannot be burned. this device is onley good for horrisontal boilers. such as return tublers, silinders and flew boilers. and I guarnte to give more and better steam with one boiler, then two of heny other boiler on the marKet. of the same horse power. if you accept this offer for me to place you one in free of charge. will not cost you one cent. and you to make an affedavit to the effect of its merrits. and answer 25 inquires as to its eficancy. it is as astounding as the arepaleen. if you wish to give this a triall let me Know when i can se you and were. and we can soon arange to have it don. at the shortist notice. in ordering give the diametr of the boiler. Patent appid for.

Yours truly,
(Signed) ——— ———

P. S. as soon as i get this placed I want to make a trolley that will not come of the wires in rounding a turn. i have seen them com of on the strait lines also.

Flexible Gusset Stay

A flexible gusset stay adapted chiefly to Lancashire boilers has been introduced in England by the Vulcan Boiler & General Insurance Co., Ltd., of Manchester. The flexible stay is shown in Fig. 1 and is a modification of the ordinary rigid gusset stay, consisting of the usual double angles riveted to the shell and front end plate. The gusset web plate is rigidly riveted to the angles on the shell but instead of the rivets usually used, for the attachment of the web plate to the angles of the front end plate, turned bolts are substituted. The bolt holes in the gusset plate are elongated, the clearances varying from a maximum at the bottom to nothing at the top and in this way a certain amount of end-plate movement is permitted before the stay comes into operation. By varying the elongation of the bolt holes it is possible to design a stay so that the end plate is free to move through any predetermined distance and moreover by this system the load can be distributed evenly over all the bolts, whereas in the ordinary system of rigid staying, practically the entire load comes on the toe rivets only. When the conditions of working are severe, such an arrangement of staying is of great value in reducing the strains that tend to cause grooving or leaking at the rivets and seams on the front end. With rigid staying practically all the movement due to furnace expansion has to be taken up by the front-end flanges of the furnaces and a strip of plate usually about 10 to 11 in. wide situated between the crowns of the furnaces and the bottom or toe rivets in the attachment of the gusset angle to the end plates. With the Vulcan system of staying, the deflection is not localized, but is distributed over that portion of the end plate situated between the furnace crown and the outer circumferential riveting by which the plate is attached to the shell and the angle through which the plate is bent to this movement is comparatively small. Hence severe local stresses are avoided.

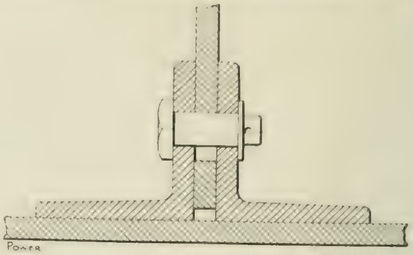


Fig. 1. Showing Elongated Bolt Hole in Gusset Stay

These stays have been used in boilers and have stopped leaks that were troublesome with rigid gusset stays. The chief purpose of this stay is to prevent grooving due to distortion of the head by the expansion of the furnace plates.

The curves, Fig. 2, show the deflection of the head, furnace plates and the bottom of the stays in a Lancashire boiler. The boiler tested was 8 ft. in diameter, made for an ordinary working pressure of 160 lb. The end plate was $\frac{3}{4}$ in. thick, fitted with five flexible gusset stays above the furnace at the front end and two ordinary rigid gusset stays below. The bottom bolt hole of the center stay was elongated $\frac{9}{32}$ in., those in the intermediate stays $\frac{1}{4}$ in., and in the wing stays $\frac{5}{32}$ in. It will be noted that the deflections of the boiler under steam pressure were much greater than the corresponding cold-water pressure, due principally to the fact that the expansive movement of the furnace forces out the end plate. When steam at about 212 deg. F. was just issuing from the test tap, the upper parts of the furnace were expanded $\frac{1}{16}$ in. more than the shell of the boiler, while at 40 lb., steam pressure the difference at these parts equaled that caused by a cold-water pressure of 160 lb. At 120 lb. steam pressure the expansion was just equal to that produced by the maximum cold-water test pressure of 260 lb. per square inch. The deflection of the bottom ends of the three center gusset stays were of a similar amount and at the full working steam pressure of 160 lb. the bolts were just in contact with the ends of the elongated holes in the gusset plates. Hence the end plate was practically free to move forward until the full working pressure was reached.

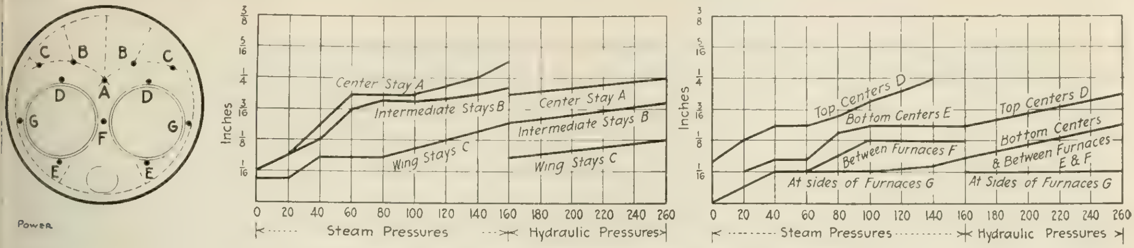


Fig. 2. Curves of Deflections in Boiler and Furnace

⁂

Oil Burners for Power Plant

By J. J. McIntosh

SYNOPSIS—The use of air and steam for atomization and different types of burner on the market.

⁂

For power-plant work steam is almost entirely used in the burners as an atomizing medium. The extra equipment required for air for this purpose is a serious drawback to its use. It not only increases the complication of an oil-burning system, but also adds to the risk of interrupted service. As it is convenient to use steam for this work and as air for atomizing offers no advantage over steam by saving fuel, air is never used unless there is a special reason for it. The amount of steam used for atomization varies in different plants. If the furnace temperature is high and the oil fed to the burners is preheated, it will require less force to atomize the oil. Oils with an asphaltum base are heavy and of a viscous character, and by increasing their temperature their viscosity is rapidly reduced. If the furnace is properly arranged, the amount of atomizing force required will be small, because the heat from the brick will immediately gasify the oil, and, if sufficient oxygen is present, it will ignite and complete combustion will ensue. Atomizing a pound of oil requires from 0.25 to 0.5 lb. of steam.

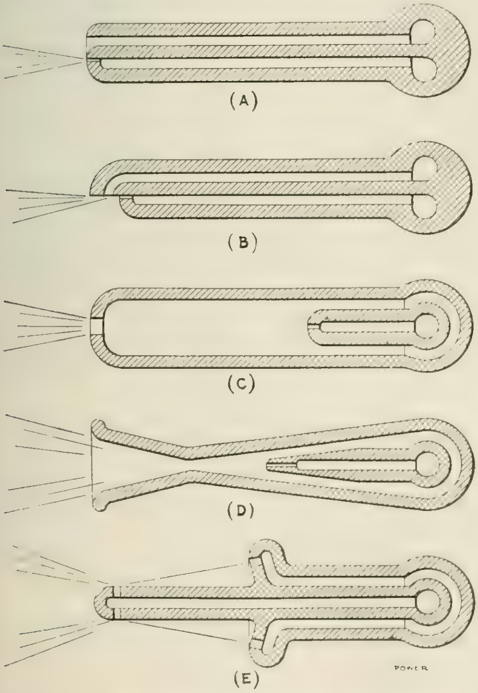


Fig. 1. Five General Classes of Burner

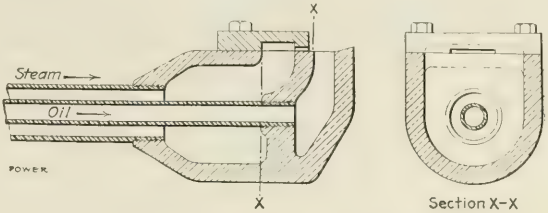


Fig. 2. Worden Burner

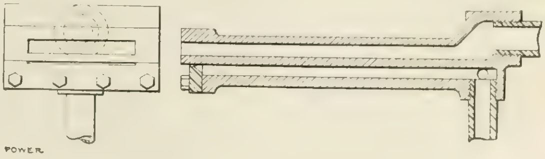


Fig. 3. Booth Burner

Air is used almost entirely for atomization in certain industrial operations where a high furnace temperature is desired. It is used also in cement kilns where a long flame is desired and in operations where steam would have a detrimental effect on the products manufactured. It is still being used to a certain extent on ocean-going vessels but is slowly giving way to mechanical atomization. As space is at a high premium on such vessels, and, as steam for atomization would require from 3 to 8 per cent. of the total water carried, its use is limited. The amount of air required varies considerably, but usually ranges from 0.2 to 0.55 lb. per pound of oil.

Oil is also atomized by mechanical action. The oil is heated to a high temperature (about 260 deg. F.) and the oil pressure is kept in accordance with the temperature to prevent the formation of gas. However, the moment the oil leaves the burners under the boilers, the pressure is removed from the oil, and it flashes into the finest atoms. This physical action is assisted by centrifugal spray nozzles, so as to give a more perfect and intimate mixture with the air.

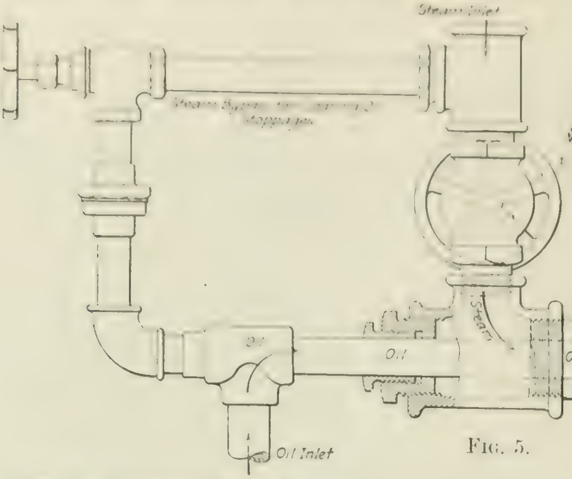


Fig. 5.

Fig. 4. Peabody No. 1 Burner

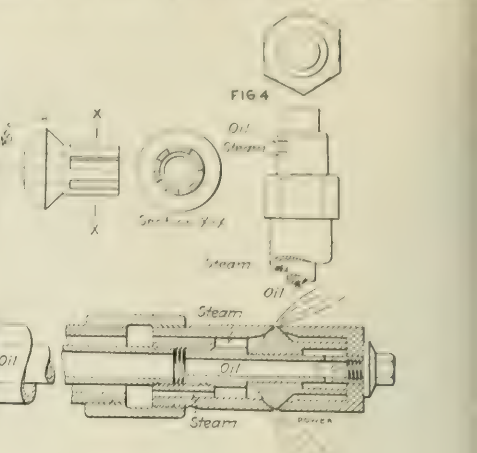


Fig. 5. McDonald Burner

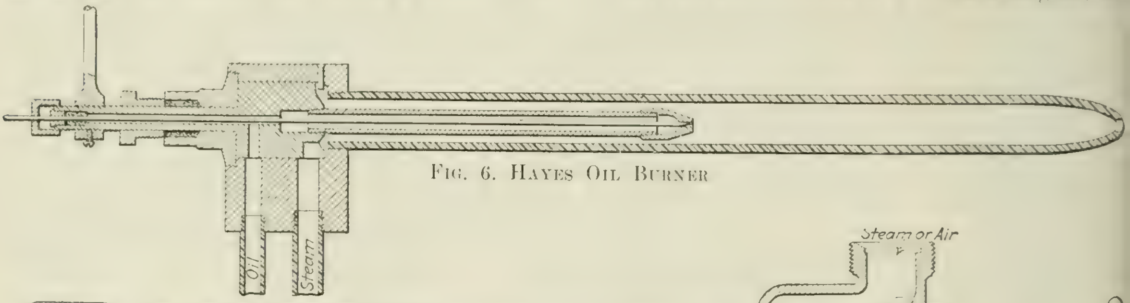


Fig. 6. Hayes Oil Burner

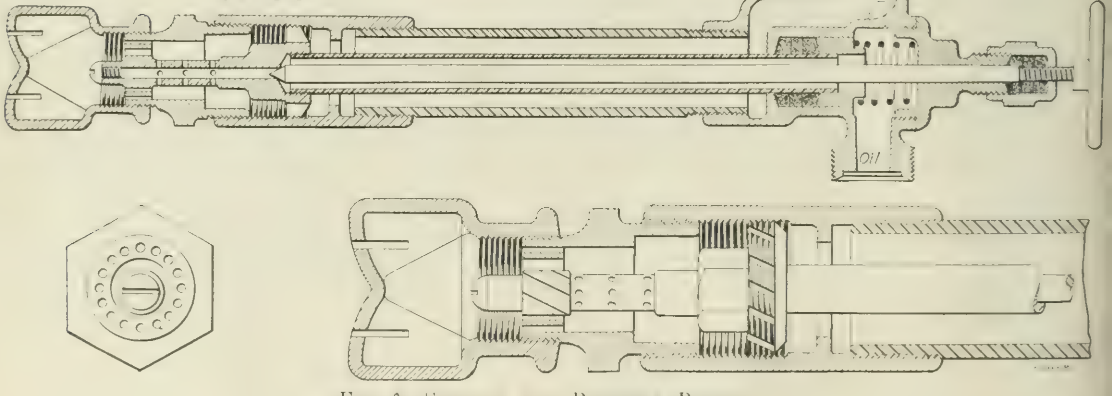


Fig. 7. Staples and Pfeiffer Burner

Burners

There have been hundreds of oil burners designed, but the majority of them never got further than the paper on which they were laid out. It has been the pet hobby of many engineers—and others—to design oil burners. As a matter of fact, the design of an oil burner is not nearly as important as the arrangement of the furnace in the economic burning of oil. This does not mean that any sort of a contrivance that will squirt oil into the furnace will do for an oil burner. Oil must be gasified or broken up into a fine spray before it can be burned completely. If the oil is not broken up into a fine spray or gasified, complete combustion will not ensue, and small particles of unconsumed oil will fall to the brickwork, forming carbon, which will accumulate and build up; this condition, of course, represents a waste. Provided that a burner completely atomizes the oil, nothing further in the design of a burner will result in a higher economy, with the exception of the amount of atomizing agent required to bring this about. The best burner is obviously the one that completely atomizes the oil with a minimum amount of steam or air. It must also be designed to permit rapid removal from the furnace for examination and all parts subject to wear must be made easily renewable.

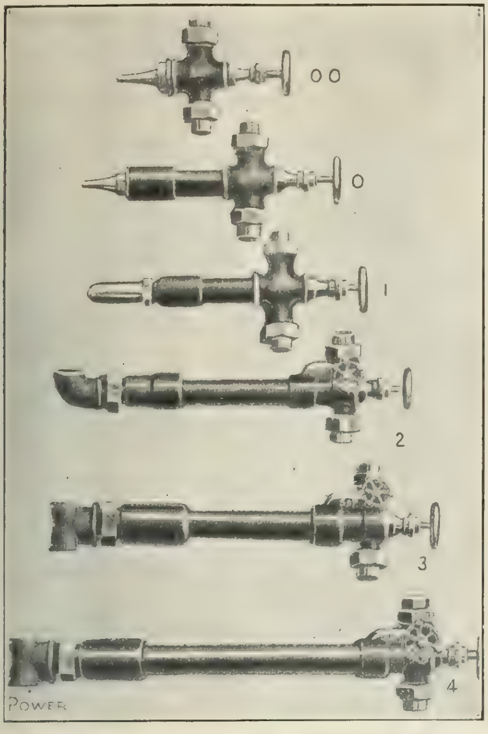


Fig. 8. Staples and Pfeiffer Burners for Melting Metals and for Boiler Use

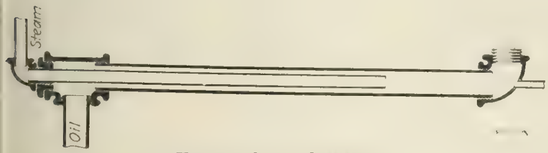


Fig. 9. Pipe Burner

The first burners to mechanically atomize oil were not successful when used with oils containing an asphaltum base, because this type of burner has a tendency to carbonize the oil. The carbonized oil stops the passages and hinders the working of the burner. In several types of mechanical burner now on the market, this tendency to carbonize seems to have been entirely overcome. In fact, mechanical oil-burning systems are finding a wide application in marine work and have made considerable headway in stationary work.

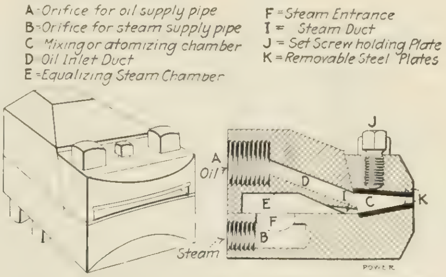

A-Orifice for oil supply pipe
B-Orifice for steam supply pipe
C Mixing or atomizing chamber
D Oil Inlet Duct
E-Equalizing Steam Chamber
F=Steam Entrance
I = Steam Duct
J = Set Screw holding Plate
K=Removable Steel Plates
Oil
Steam
A
B
C
D
E
F
I
J
K
POWER

Fig. 10. Hammel Inside-Mixer Burner

Of the thousands of patents that have been granted for oil burners, it has been found possible to divide them into five different classes. These five general classes are shown in Fig. 1.

In illustration *A*, the drooling burner, oil drops out of an orifice on a flaring jet of steam and is thus atomized. In the atomizer burner *B* the oil drops directly on the steam jet, or, in other words, is swept off by a brush of steam or air. In the chamber burner *C* oil and steam intermingle within the burner itself and issue from it in the form of a mixture. The oil is further broken up by the expanding action of the steam as it leaves the burner. The injector burner *D* is similar to the steam injector. Its design enables it to draw oil from a tank and force it into the furnace. In the projector burner *E* oil is pumped to the burner and in issuing from the burner tip is taken up by a jet of steam.

Burners may be further divided into the outside- and inside-mixer types. In the outside-mixer type of oil burner, the oil and the atomizing medium do not come into contact with each other until they are forced into the furnace. In some types the oil enters the furnace through an orifice, in the burner, above the steam orifice, drops upon a jet of steam and is thereby atomized. In other types the oil issues from the burner below the steam, but the orifice is so designed that the oil leaves the burner at nearly right angles to the jet of steam. As a result the oil jet strikes the steam jet and is thus broken up into fine particles.

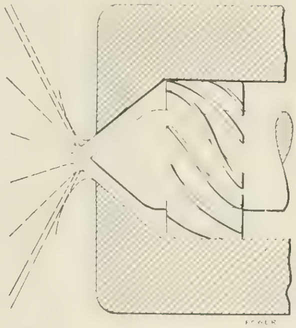


Fig. 11. Formation of Spray in Mechanical Burner

In the inside-mixer type of burner, the oil and atomizthe medium come into contact with each other before leaving the burner. The result is that the oil is broken up within the burner itself. The adherents of this type of burner claim that it will atomize either cold or heated oil with better success than the outside-mixer type.

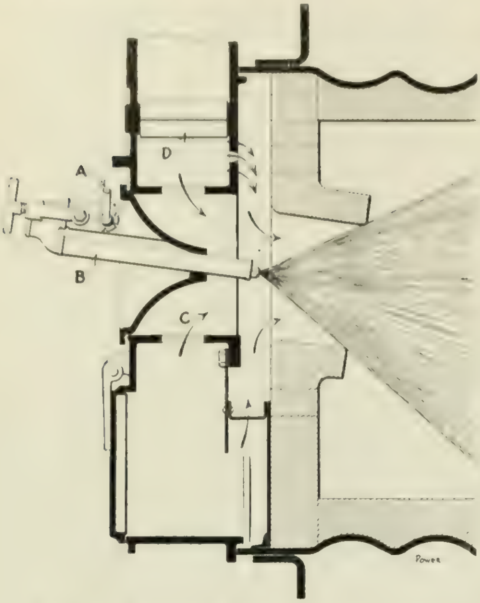


FIG. 12. KOERTING MECHANICAL BURNER

Fig. 2 shows the Worden burner, which is of the outside-mixer type. It will be noticed that the oil flows from the burner at right angles to the jet of steam. Fig. 3 illustrates the Booth burner, which is commonly called the Santa Fé burner, because of its wide application on the locomotives of the Santa Fé Railway Co. Fig. 4 illustrates the Peabody No. 1 burner, which is used to a large extent on Babcock & Wilcox boilers. The McDonald oil burner is shown in Fig. 5. The action of this burner is similar to that of the atomizer burner shown at *B*, Fig. 1. This burner issues a round flame.

Fig. 6 shows the Hayes oil burner, which is essentially an inside-mixer burner and issues a round flame. Fig. 7 illustrates the Staples and Pfeiffer oil burner and Fig. 8 shows burners of the same make. No. 60 is for melting brass, copper, lead, etc.; No. 0 is for melting steel and iron and also for heating steel and iron for bending, flanging, etc.; No. 1 for tempering, forging, annealing and for brick and lime kilns; No. 2 for bakeries, ovens, retorts, heaters and small boilers; No. 3 for all standard makes and sizes of boilers, furnaces, kilns, etc.; No. 4 for large boilers and furnaces in general.

Fig. 9 shows a pipe burner that is popular with some engineers. It is of the inside-mixer type. The orifice in the ell should be about $\frac{3}{32}$ in. in width and the length of the orifice will depend upon the width of the furnace. The end of the steam pipe in the burner should be about 6 in. from the orifice.

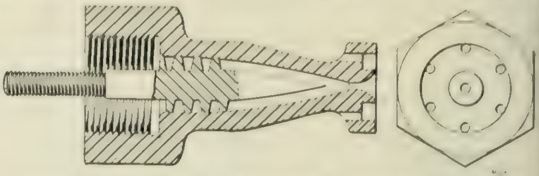


FIG. 13. HEAD OF ANOTHER KOERTING BURNER

Fig. 10 illustrates the Hammel inside-mixer burner which is held in high regard by many. It has been estimated that there are over 10,000 of these burners in use.

Fig. 11 shows the formation of spray in a mechanical burner, under the joint action of the pump pressure and the centrifugal action of the screw-guide blades. Fig. 12 shows the Koerting mechanical oil burner in action. In the drawing *A* is the oil inlet, *B* the burner, *D* the damper and *C* the air inlet. Fig. 13 shows the burner head of one form of Koerting burner.

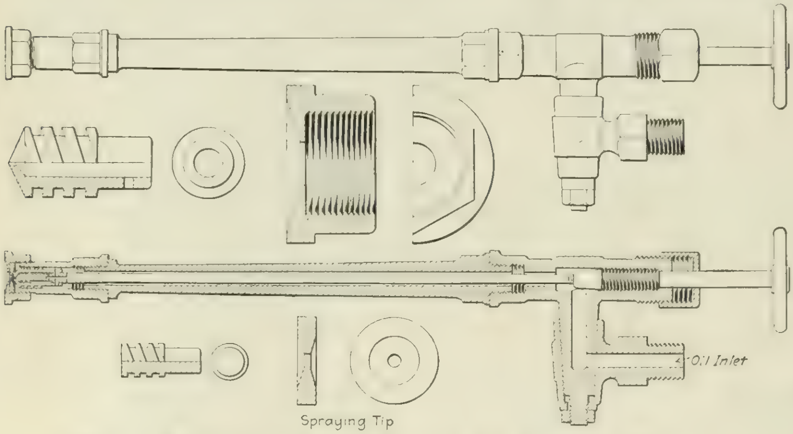


FIG. 14. MECHANICAL BURNER USED IN OIL FIELDS OF RUSSIA

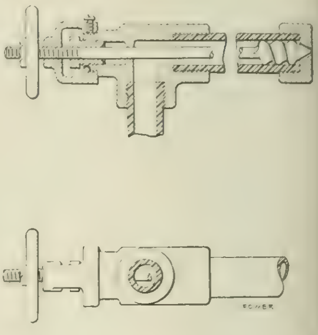


FIG. 15. MECHANICAL BURNER USED BY U. S. NAVAL FUEL-OIL BOARD

Fig. 14 illutsrates a form of mechanical burner used in the Baku oil fields in Russia, and in Fig. 15 is shown a mechanical oil burner designed for use by the United States Naval Fuel Oil Board.

The burners illustrated in Figs. 2, 3, 4, 7, 9 and 10 produce a flat fan-shaped flame, and experience has proved that burners producing a flat flame are the most efficient for the majority of stationary boilers.

Composite Generating Plant

By H. Winfield Secor

SYNOPSIS—In the daytime, alternating current is supplied by a turbo-generator and direct current through a synchronous motor-generator set. At night, the alternating-current load is much smaller than the direct-current, hence the turbo-alternator is shut down, and an engine-driven dynamo started. Alternating current is then supplied by the motor-generator set reversed.

*

This generating plant was designed to supply both three-phase alternating current at 250 volts and direct current at 220 volts for the Pennsylvania Railroad Co.'s locomotive repair shop at Trenton, N. J. Besides, there are two Thomson-Houston series arc-light dynamos supplying direct current at 8500 volts for arc lamps throughout the shop and yard.

The prime movers comprise a 500 kw. turbo-alternator delivering three-phase alternating current at 250 volts and 60 cycles; a 200-kw. synchronous motor-generator set with a 220-volt compound-wound generator delivering direct current to some of the apparatus about the shop, particularly the crane motors, and finally, an auxiliary source of direct current at 220 volts from a 200-hp. tandem compound engine-driven unit.

There are two exciters, each driven at 1500 r.p.m. through a 10 to 1 reduction gear by a 75-hp. De Laval turbine. One of these exciter units is run during the day and the other at night. The plant is operated condensing for the large engine and turbo unit. The 500-kw. turbine is started slowly noncondensing, and, after it has reached normal speed, is thrown onto the condenser. It is never started on the condenser, as the water-sealing arrangement of this turbine does not become effective until practically normal speed has been attained.

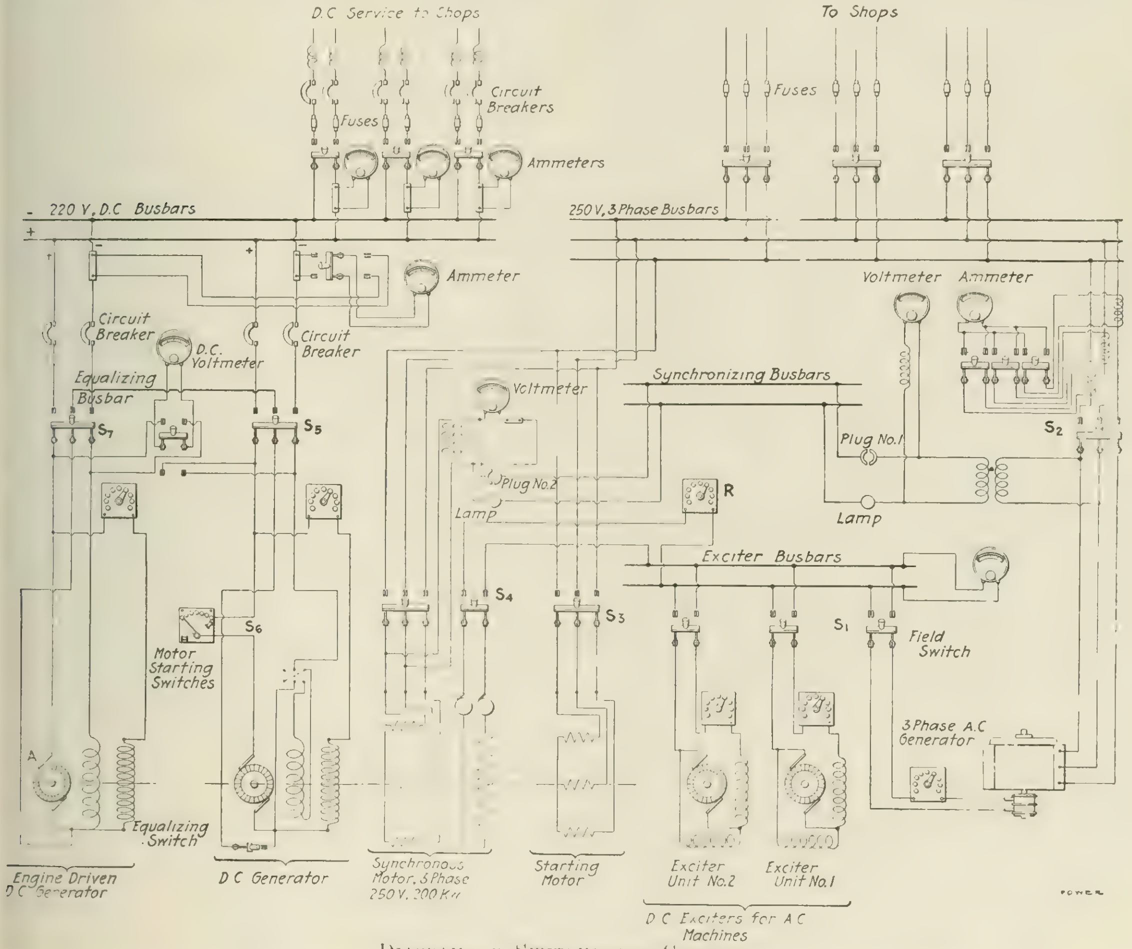


Diagram of Switchboard Circuits

The main switchboard is divided into two sections of five panels each. The right-hand section is for the alternating-current switching apparatus, including the exciters, while the left-hand side controls the direct-current units and circuits.

The regular daily procedure in running this plant is as follows: One of the exciter units is started and its voltage adjusted to about 115 volts. At the same time the 500-kw. turbo-alternator is brought up to speed and the field excitation switch S_1 is closed. The alternating-current voltage is then adjusted by means of the field rheostat, or, if necessary, by regulating the exciter voltage, and the main switch S_2 is then closed, making the main busbars alive, so that any desired alternating-current service is readily supplied by closing the proper shop-circuit switches. The fuses only protect the alternating current section of the switchboard and its supply units from overload or short-circuits on the shop lines, the generator panels having no protective devices.

As some direct current is required for the motors and other devices, such as heaters, annealers, etc., the synchrononous motor-generator set is used to supply this service. This set is brought up to synchronous speed by a squirrel-cage induction motor directly connected to the shaft. After having attained approximately synchronous speed the field excitation switch S_4 for the synchronous motor is closed, and the synchronizing plugs 1 and 2 are inserted in the receptacles. When the set approaches synchronism the main motor switch is thrown in quickly. The motor is now ready to take its load, and the switch S_3 on the starting motor can be opened. If difficulty is had in synchronizing the two machines, the starting motor switch may be opened and closed quickly, so as to slightly change the phase relation between the motor and the alternator. This may have to be done several times before the operator can get the "dark" period sufficiently long to enable him to switch in the set.

After the motor-generator set has been synchronized and the direct-current potential adjusted to 220 volts, by means of the shunt field rheostat, the generator switch S_5 can be closed, thus energizing the direct-current busbars. The circuit-breakers are always closed before the main switch, for in case of unforeseen trouble on the line, if the circuit-breakers were closed manually after the switches they would not offer any automatic protection, and serious damage to the generator might result.

It is to be noted that the special direct-current motor-starting switch S_6 is equipped with suitable resistance sets which are always left closed when the machine is to be operated as a dynamo to supply 220 volts to the switchboard.

The plant is now running under normal day conditions, and toward evening, when the time approaches to shut down the 500-kw. alternator and the synchronous motor-generator set (operating as a motor), the steam-engine-driven unit is brought up to speed and its voltage adjusted to correspond with that of the direct-current dynamo of the motor-generator set. First, the circuit-breakers of the incoming machine and then the switch S_7 are closed. The load on both direct-current generators is quickly balanced by manipulating their field rheostats, and as the direct-current end of the motor-generator set is to be cut out, the load is reduced to approximately zero by cutting out resistance in the field circuit of the incoming machine and cutting in resistance in the field circuit of the outgoing machine. When the ammeter on the latter indicates practically zero load its main circuit-breakers are tripped, cutting it out of service. From the foregoing it is evident that the direct-current load on the switchboard has been carried right along without any interruption, by operating the two direct-current generators in parallel for a short time.

At this stage the usual practice is to cut off temporarily all the alternating-current load by prearrangement with the shop department, and the shop-circuit switches are accordingly opened when the load has dropped to a very low point. The synchronous motor of the set is also cut out by opening its main switch and then its field excitation switch S_4. This leaves the motor-generator set dead. The alternating-current load having been reduced to zero, the 500-kw. turbo unit has its main switch S_2 opened, but just previous to this its field excitation switch S_1 is opened, only half way at first, allowing the blades to engage with the field discharge resistance for a few minutes, which prevents the sudden production of a high induced electromotive force, which might puncture the field windings. The throttle on the steam turbine is then closed and the turbo-alternator is brought to rest. The exciter unit is also shut down.

Usually, some alternating-current service is desired at night. This is supplied from the synchronous motor-generator set operated as a three-phase alternator, excitation being furnished by the spare exciter. The direct-current machine is readily started now as a compound motor. In order that the series and shunt windings shall not oppose one another, however, it is first necessary to reverse the series field connections by means of the double-throw switch shown. The circuit-breakers are next closed, then the main switch, and finally the starting switch S_6 is slowly closed step by step until it is all the way in and the set has attained normal speed. The field excitation switch S_4 of the synchonous machine is then closed, and the alternating-current three-phase voltage is adjusted by means of the field regulator R, and also the exciter's field rheostat, if necessary. When the alternating-current voltmeter indicates the correct potential, the main switch may be closed, and the busbars are made alive. If desired, the alternating-current load on the turbo-alternator could be transferred to the motor-generator by starting up this set as just described and then synchronizing the two alternating-current machines to prevent interruption of service.

It is poor practice generally to solidly connect (electrically) a large synchronous motor and an alternator, without automatic circuit-breakers in the line. Sometimes the direct-current load on the generator becomes too great and the synchonous motor, owing to its inherent characteristics, refuses to stand up to the load and comes to a dead stop. The motor, with but little resistance and fair impedance, is short-circuited directly across the line of the alternator and throws a heavy load on the latter unless the motor switch is very quickly opened. This occurred once in the writer's experience, and before the motor switch had been opened the alternator started to smoke. This took place about 11 a.m. and the alternator stood up for the rest of the day, but that night the revolving bipolar field gave out and necessitated calling out a night shift to put in a spare field, which luckily was on hand. One of the revolving field coil terminals had become charred until it could barely hold together, and finally parted, thus opening the field circuit. All this trouble, and any repetition of it, could have been avoided by installing circuit-breakers on the alternator panel, or at least by putting a set of fuses between it and the main busbars.

Transit and Level for Engine Aligning

By L. L. Brewster

SYNOPSIS—Directions are given for using an engineer's transit and level in aligning an engine, the installation of a gas engine being used as an example. The value of the instrument for other work is also pointed out.

*

An engineer's transit, when available, is a valuable aid in quickly and accurately doing the aligning incidental to setting up any form of steam or gas engine or compressor unit, as well as line shafting. If the transit is accurately adjusted it may be used as a level. If it has no level under the telescope, a surveyor's level can be used.

The method of using the instrument may be understood from the following account of the installation of a large double-acting, twin, tandem gas engine.

Before the engine was placed, a set of reference lines were located on the engine-room floor, as shown in Fig. 1, i.e., the two center lines of the engine and the center line of the shaft. Small plugs were driven in holes cut in the concrete floor at the end of each line. Tacks were driven in the plugs at the point of intersection of two scratches, made with a knife blade.

Two lines *AB* and *CD* were checked by measuring the distance between their ends with a steel tape, setting up the transit over all four points, *A, B, C* and *D,* and successively turning right angles with the transit and "checking in" on the points. The line *EF* is located by "setting up" over the intersection of this line with the lines *AB* and *CD* and checking the angles and distances, as in the case of the base lines *AB* and *CD.* These points were purposely located some distance from the position of the engine to be used as permanent reference points over which to set up the transit and so reëstablish any of the lines at any time.

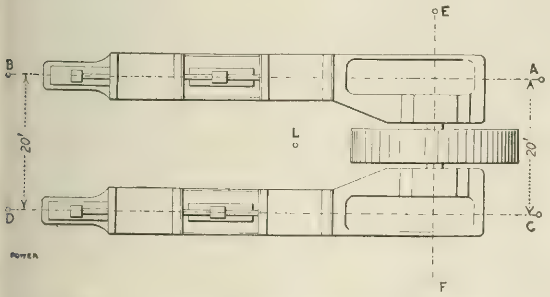


Fig. 1. Center Lines through Engine

When the parts of the engine were placed, their location on the foundation could be very closely established by comparatively rough measurements, and after complete assembly and before the engines were "grouted in" on the foundation, the aligning of the engine was accurately done by using the transit.

Setting the transit over the point *A* and taking a sight on the point *B,* any point on the engine which is intersected by the vertical cross-hair in the transit will be in the vertical plane of the center line of this half of the engine. Since the reciprocating parts of the engine are those which must be on a center in the vertical and horizontal plane it is necessary to accurately check their location. As these reciprocating parts are nearly all circular in section, their centers are accurately located by the contrivance shown in Fig. 2.

Care should be taken that the angle of the two bottom legs is the same on each side of the center line. This center line *GH* should be drawn in the exact center of the flat vertical member, and the plate at the top which supports a machinist's level should also be at exactly right angles to the center line *GH.* Then if the contrivance is placed over a piston rod, for instance, the line *GH* will be vertically over the center line of the rod when the bubble in the level is centered and the line *GH* may be used as the target at which to sight the transit.

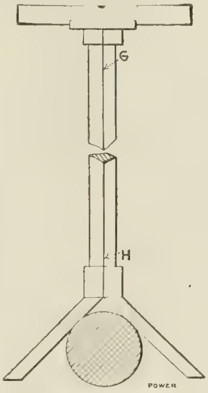


Fig. 2. Centering a Rod

If any part of the engine is out of line, the error will be in the distance between the line *GH* and the line of sight through the transit as previously established from *A* to *B,* Fig. 1. By moving that part of the engine which is out of line until the line *GH* comes into the line of sight through the transit, that part of the engine will be brought into coincidence with the center line of the engine.

Other parts of the engine not of circular section, but the center of which can be accurately established by measurement, can be checked by the use of a plumb bob. All points along the engine can thus be brought into line in a vertical direction usually from a single setting of the transit; the operation for one side of the engine is the same as that for the other side.

In the same manner, by setting the transit over the points *E* or *F* and sighting to the opposite point, the axis of the transit and the line of sight are then in a vertical plane with the axis of the engine shaft and all points along the shaft may be brought into line by methods similar to those just described.

Having accurately located the base lines, in which case it is certain that the axis lines are parallel to one another and exactly perpendicular to the shaft line, the instrument is a positive check and is also an accurate method of aligning the various parts of the engine.

All the work described to this point, however, refers to location of the vertical plane only. To check the parts of the engine for their proper relative elevations, the transit must be used as a level, or a surveyor's level brought into service. The usual leveling-up process of stretching a wire through the cylinders from one end to the other is accurate, but where the engine is long (in the case under description it was over 70 ft.) allowance must be made for the sag of the wire which is bound to occur.

To do accurate level work the distance from the instrument to the points at which readings are taken (the length of the sights) must be as nearly equal as possible, although for the short distances of the present case the error would be inappreciable. However, if convenient, it is best to set up the level at some such central point as shown at *L*, Fig. 1. By establishing a bench mark at some fixed point on the floor of the engine room, the height of the instrument may be ascertained also the relative heights of all parts in reference to the bench mark.

For those not familiar with the use of an engineer's level and rod, the process of ascertaining relative elevations is as follows:

Suppose we arbitrarily assume a "bench mark" to be, say, 100 ft. above some imaginary datum plane. Then, if the instrument is level and the sight is taken on the rod placed over the bench mark, the rod reading added to the elevation of the bench mark will be the elevation of the line of sight of the level above the bench mark. Suppose the rod reading to be 5 ft. 6 in., then the elevation of the line of sight through the level relative to the datum plane will be 100 ft. plus 5 ft. 6 in., or 105 ft. 6 in. This is known as the height of the instrument.

Suppose, now, it is desired to check up the elevation of the center line of the engine, assuming that the diameter of the piston rod is 12 in. and the reading of the rod placed vertically on top of the tail rod is 2 ft. This means that the top of the tail rod is 2 ft. below the level of the instrument, or its elevation relative to the datum plane is 105 ft. 6 in. minus 2 ft., or 103 ft. 6 in. But, since the diameter of the rod is 12 in., the elevation of its center line will be 6 in. below this point, or at an elevation of 103 ft.

In like manner one may ascertain the relative elevation of any other points on the piston rod, as, for instance, between the cylinders or at the forward end of the head-end cylinder. If these elevations are not the same as at other points, the difference will be accurately known and the elevation may be adjusted until all parts are at exactly the same elevation.

Evidently, subtracting rod readings from the elevation of the instrument will give elevations at the bottom of the rod and the elevation of points anywhere on the engine is thus easily established if their distance above or below the bottom of the rod is known, and this can usually be easily ascertained.

The rod used for this work should have an accurate scale of fine divisions, but usually, for accurate work, a small steel mechanic's scale must be used with the rod. By holding this scale against the rod and using the edge of it as a target line which is to be brought into coincidence with the line of sight through the level, as indicated by the horizontal cross-hair, a very accurate rod reading can be made. The best time to do this work is at night, especially if the engine room is hot during the day time and there is vibration due to other moving machinery.

While the operations described may seem somewhat complex and difficult, they are really quite simple and can be done quite rapidly. The rapidity of operation, however, should not be such as to interfere with accurate work.

The writer has discussed this method of aligning engines with several erecting engineers, and all who use it agree that it is the most accurate and most expeditious method and any engineer with little practice can handle the transit or level and probably do more accurate work than by any other method.

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Gravity Values of Oil

In the article in the issue of Jan. 6, "Physical Properties of Fuel Oil," the following equation was given for the relation between specific gravity and degrees Baumé:

$$\textit{specific gravity} = \frac{140}{130 + B}$$

This is perfectly correct for the United States standard degree Baumé, but according to H. H. Hall, of San Francisco, it is not the one commonly used in the oil business. Tagliabue's "Manual for Inspectors of Coal Oil" is in almost universal use. This book gives a table of the relation between specific gravity and degrees Baumé which is based on the equation

$$\textit{specific gravity} = \frac{141.5}{131.5 + B}$$

Incidentally, in the transposition of the above formula to obtain the second one for Baumé gravity, an error crept into the right-hand member of the equation. The formula should read

$$\textit{Baume gravity} = \frac{sp.gr.}{140} - 130$$

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The Power Problem in the Electrolytic Deposition of Metals

Power supply for the refining of metals by electrolysis and electroplating, is different from that for any other purpose. The voltages used are relatively lower and the current of higher amperage than in most other applications, and the conditions so different that they can be met only by apparatus of special design. Satisfactory and reliable service are of prime importance, and economy the next consideration. In the solution of the problem there have been involved the efforts of the three professions represented by the American Electrochemical Society, the American Institute of Electrical Engineers and the American Society of Mechanical Engineers so that it was quite appropriate that the New York sections of these three societies should have one of their monthly meetings a joint one for the consideration of this topic. Such a meeting was held Jan. 9, in the Engineering Societies Building with C. O. Mailloux, president of the American Institute of Electrical Engineers, presiding.

The requirements in the problem from the standpoint of the electrochemist were presented in a paper by Lawrence Addicks. F. D. Newbury, for the electrical engineers, dealt with the sources of direct current for electrochemical processes and H. E. Longwell treated the mechanical side of the question in the selection of the most suitable prime mover.

The electrolytic refining of copper is one of the largest of the industries concerned. Most copper today is so refined and the principal plants doing the work are in the vicinity of New York, so that it was natural that this special phase of the subject received most discussion, particularly as it could be taken as typical of this class of electrolytic processes.

CONDITIONS OF THE PROBLEM

Considering only the so called multiple system of refining, where the electrodes in a tank are in multiple, and the tanks on a circuit in series, the following power limitations are imposed by present practice:

(a) Direct current (obviously required by the nature of the process).

(b) An amperage of, say, 8000 to 15,000, fixed by the current density and the electrode surface per tank. Around New York a current density of about 20 amp. per sq.ft. of active cathode surface is used and as much electrode surface per tank as in 30 pairs of electrodes each 3 ft. square.

(c) From 100 to 200 volts per circuit would appear to be the practicable limits of voltage with a preference toward the lower, or not to exceed 150 volts.

(d) For, a typical case then a unit of about 1000 kw., although larger than most now installed, is the probable size for a new installation.

(e) Difficulties arising from the tendencies for current leakage indicate the desirability of electrically independent circuits.

(f) Uniform conditions are essential calling for constant current and voltage varying not more than 20 per cent. either way from normal.

(g) The load factor will be practically 100 per cent. for both momentary and 24-hr. loads.

(h) It being necessary to heat the electrolyte, steam is needed. Exhaust steam may be used and, roughly, one-fourth of that from the engines will answer. Additional steam is required for light, power, compressed air and pumping. If the power is other than from steam, waste heat boilers attached to the reverberatory furnaces will supply all steam for electrolyte heating and other uses.

(i) Three thousand to 9000-kw. plants are about the sizes to be considered.

Near New York steam power is logical at present.

Concluding, the author states: "The plant of the future may consist of gas-driven units, of large capacity alternating-current, turbo-generators driving motor generators of smaller size, of compound reciprocating engines exhausting into a trunk main from which exhaust steam turbines are fed, of multiple expansion reciprocating engines, of turbine-driven unipolar generators, or of some combination of these. Spare units must be provided in sufficient proportion to give absolute reliability of service."

ELECTRICAL LIMITATIONS

As to the prime mover, Mr. Newbury declared that in modern installations, steam turbines and waterwheels with their relatively high speed are most important. Reciprocating steam engines are important mainly in combination with low-pressure turbines. So far, gas and oil engines have been little applied, but the rapid development of the Diesel engine may make it a factor.

The large currents and high speeds of the preferred prime movers make the design of direct-current machinery a problem on account of commutation. After dealing with this the speaker took up the distribution problem and the questions of voltage variation and continuity of service.

Summarized, his conclusions and recommendations were:

"Of the methods of power supply using steam turbines that are available:

(a) Direct-connected direct-current turbo-generators are available only in relatively small units, and cannot be designed as conservatively from the commutation standpoint as is desirable.

(b) Unipolar generators driven by turbines have proved unsatisfactory on account of current collection difficulties.

(c) The standard medium-speed direct-current generator connected to a high-speed turbine through gearing affords a satisfactory unit.

(d) The combined alternating-current turbo-generator and converter unit probably affords the best all-around method. It is economical, reliable and flexible. Its particular fields of application are where large units and long transmissions are required.

In waterpower plants, direct-connected direct-current generators and alternating-current generators with converters are available. The combined alternating-current-direct-current equipment is usually the most reliable and economical.

With reciprocating engine units, there is no reason for considering other methods than the direct-connected slow-speed generator.

From the many schemes proposed for the generation of direct current for electrochemical plants, two plans assuming steam-turbine prime movers have decided advantages in efficiency and reliability and flexibility in operation. These are the gear-driven commutator-type generator where the distance between the power plant and the place of utilization is short, and the combined alternating-current generator and synchronous converter plant when this distance becomes too great for economical low-voltage transmission or the units become too large for economical turbine speeds.

CHOOSING THE PRIME MOVER

H. E. Longwell laid particular emphasis in the forepart of his paper on the folly of striving for highest steam or fuel economy when the saving may not be worth while or may entail another loss of even greater magnitude. The extra interest, depreciation, etc., on a more expensive installation may offset the advantage of a higher fuel economy. On this ground the speaker felt that gas-engine equipment could be eliminated from serious consideration, especially as a location could be chosen most favorable for steam-plant economy.

It was figured that the waste heat boilers connected to the reverberatory furnaces should supply enough steam for the auxiliaries and the exhaust from the latter should be enough to heat the electrolyte. Even with gas engine-driven main generating units this heat would need to be utilized. The principal practical difficulty is that the tanks run continuously and the furnaces close down on Sundays, making a considerable stand-by boiler plant necessary. This alone would discount all theoretical advantages of gas power.

The speaker doubts that the reciprocating engine and low-pressure turbine combination would be justified, except possibly where the reciprocating engine is already installed. His leaning is evidently toward the steam turbine alone and he feels that with the reduction gearing now available to reduce the high speed of the turbine to suitable direct driving speed for direct-current machinery, the last objection to the turbine has been removed. While the geared direct-current unit costs more than an alternating-current, turbo-generator unit of the same capacity, it is cheaper and somewhat more efficient than the combination of an alternating-current unit and rotary converter.

Under favorable conditions, the speaker believes a good turbine-driven plant of from 6000 to 9000 kw. can be installed for about $75 per kw., and operated to produce current at about 43 miles per kw.-hr.

DISCUSSION

MR. LEIGHBURY, in the general discussion of the subject, aligned himself on the side of direct current, contending that with all the necessary accessories alternating-current equipment may cost as much as direct current. Further with two stations, one generating alternating current and the other converting the alternating current to direct current, the attendance is increased.

MR. ANTISELL, of the Raritan Copper Co., stated that one point overlooked is the efficiency on part load. There is a greater falling off with turbines than with reciprocating engines.

DR. J. B. F. HERRESHOFF, of the Nichols Copper Co., gave some facts from his experience in that company. Small units (about 400 kw.) were first used, and the turbine was the first in the United States made by the Westinghouse Machine Co., and had a direct-current generator with a long commutator. This company also tried cyclic generators of 2000-kw. capacity, but they were not satisfactory, for 30 per cent. of their energy was given off in heat. Dr. Herreshoff made the statement that no reciprocating engines over 500 kw. are now being built, indicating the practical extinction of engines.

J. B. HERRESHOFF, who has designed alternating-current generators for this class of work, was called upon to discuss the electrical problems. He explained that doubling the current doubles the rate of deposition but requires four times the power. Too rapid deposition is not good as the metal is apt to be crystalline.

C. O. MAILLOUX gave his experience of some years ago in designing equipment for electrotyping. The problem was to make electrotypes faster and uniform in thickness. They were able to use a current density of 500 to 1000 amp. per sq.in. by regulating the feeding of the electrolyte to the cathode. This is not feasible in copper refining. It is theoretically possible to deposit any amount of copper with any amount of power. The speaker recommended a current density of between 15 and 60 amp per sq.in.

C. H. VOM BAUR brought up the subject of oil engines, declaring that current at 0.45c. per kw.-hr. could be produced with them.

MR. ADDICKS in closing the discussion reaffirmed his confidence in the reciprocating engine. The Diesel engine is more economical, but the sources of its fuel are too narrowly controlled and it is not yet sufficiently reliable to be very promising for electrochemical work.

MR. LONGWELL, to prove his disinterestedness, stated that he had designed engines that are now going to the scrap heap and has done no work on turbine design, but he still advocates turbines.

MR. NEWBURY explained his particular reference to steam-driven units, because of their greater interest to the copper-refining industries in the vicinity of New York. Waterwheels are more interesting to the aluminum industries and the larger power users.

Dinner to the Earl of Kintore

On the evening of Jan. [illegible] a dinner in honor of the Rt. Hon. the Earl of Kintore, P. C., G. C. M. G., was given at the Hotel Plaza. The occasion provided a chance to meet the distinguished guest who is visiting this country in the interest of the coming Anglo-American Exposition to be opened in London in May. The exposition will be held to celebrate the century of peace and progress in the arts, sciences and industries of the United States and the British Empire, it being the centenary of the Ghent Treaty.

Among the guests were Robert C. Morris, George Foster Peabody, Ludwig Nissen, Hon. Oscar S. Straus, Dr. W. F. Wilson, Hon. George W. Wickersham, Dr. Albert Shaw, Hon. Alton B. Parker, Hon. Seth Low, Henry Clews, George F. Kunz, Robert Underwood Johnson, William B. Howland, Isaac N. Seligman, Benjamin F. Tracy, Don C. Seitz, Dr. Alexander C. Humphreys, Fred R. Low, Calvin W. Rice, Prince Sapieha and R. Ross Appleton.

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Harvard College in Merger with the Massachusetts Institute of Technology—The engineering departments of Harvard University and the Massachusetts Institute of Technology are to be combined, as the result of an agreement reached tonight, according to the daily press. Heads of both institutes said the plan for coöperation constituted the most important movement toward the conservation of educational forces that the country has ever known. By the agreement the combined departments of mechanical engineering, electrical engineering, civil and sanitary engineering and mining engineering and metallurgy are to be conducted in the new buildings of the institute, now in process of construction in Cambridge. Harvard is to discontinue its schools of applied science in these departments. The president of Technology is to be the executive head of the coöperative work, and the faculty will consist of the faculty of the institute, enlarged by the addition of Harvard professors of the departments involved. Provision is made that when, in the future, the corporation of Technology selects a president, the president of Harvard is to sit with the committee on selection. It was announced that both Harvard and Technology are to remain absolutely unaffected in name, organization and in the title to property. Technology is to furnish the buildings, laboratories and equipment, together with contributions from its special and general funds. Harvard is to give some equipment and the interest on funds that it holds for education and research in these departments.

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Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commission. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.

Situations for Stationary Engineers—The Philadelphia Civil Service Commission will hold examinations Jan. 31, for three positions of stationary or operating engineer. Salaries up to $1200. Address the Civil Service Commission, room 875, City Hall.

Situation for Gas Engineer—The Philadelphia Civil Service Commission will hold an examination Jan. 31 for the position of gas engineer in the Bureau of Surveys of the Public Works department; salary, $1000. For further information address the secretary of the Civil Service Commission, Room 875, City Hall. Candidates must be citizens of the United States and residents of Philadelphia.

Situation for Marine Engineer—The Philadelphia Civil Service Commission will hold an examination Jan. 31 for the position of engineer of a police-bureau boat of the Department of Public Safety; salary, $1200. Candidates must be citizens of the United States and residents of Philadelphia. For further information address the secretary of the Civil Service Commission, Room 875, City Hall.

SOCIETY NOTES

The Brotherhood of Power Workers, the organization of which at Springfield, Mass., was commented upon in our issue of Oct. 1, 1912, pages 485 and 499, has maintained a vigorous existence, and had an encouraging growth. At one of its recent meetings W. E. Wilkinson, supervising engineer of the Ferolin Co. of America, favored them with a lecture upon Boiler Plate and Tubes.

At the meeting of the Chicago section of the American Society of Mechanical Engineers to be held Jan. 28, Bryant Bannister will present a paper upon a test made at the plant of the National Tube Co., Kewanee, Ill., on a four-pass Edge Moor boiler with Taylor stokers, which gave remarkable results with low-grade Illinois coal. Further information regarding the meeting can be had from C. W. Naylor, secretary, 121 North State St., Chicago, Ill.

An "industrial safety" conference will be held at the University of Nevada, Reno, Nev., Jan. 26 and 27 under the auspices of the Engineers' Club of the University. Representatives of the mining, electrical and transportation industries will participate and a number of exhibits and motion pictures illustrating the safety-first movement will be shown. The invited guests will be entertained at a dinner by the Engineers' Club, during which novelties and recent electrical inventions will be demonstrated.

At the Engineers' Club, Boston, Mass., on Jan. 21, Percy Day, engineer of the Falk Co., read a paper on "Herring-Bone Gears." Mr. Day was closely associated with the development of the Parsons turbine. The herring-bone type of gears is being used on some of the new navy torpedo boats. The evening of Jan. 30 will be "Tech" night at the club, when Dr. Richard C. Maclaurin, president of the Massachusetts Institute of Technology, will give an illustrated talk on "The New Technology-on-the-Charles." A house dinner will be served at 6 o'clock.

PERSONALS

W. L. Abbott, chief operating engineer of the Commonwealth Edison Co., Chicago, has been awarded the Octave Chanute medal by the Western Society of Engineers, as the author of one of the best three papers presented before that society during the year 1913.

George F. Maddock has been appointed manager of the examinations and reports department of H. M. Byllesby & Co., Chicago, succeeding Harold Almert, resigned. Mr. Maddock has been the engineering representative of Byllesby & Co. on the Pacific Coast for a number of years.

OBITUARY

JOHN HYDE

John Hyde, the mechanical engineer for the Henry Phipps properties, died at his home in Pittsburgh, Penn., on Dec. 17, 1913.

J. WALLS

J. Walls, chief engineer of the steamship "Philadelphia," died at Southampton, England, Jan. 6, just as his retirement from the service had been decided upon. During the Spanish-American War, Walls was a lieutenant on the "St. Louis." He had crossed the Atlantic 800 times.

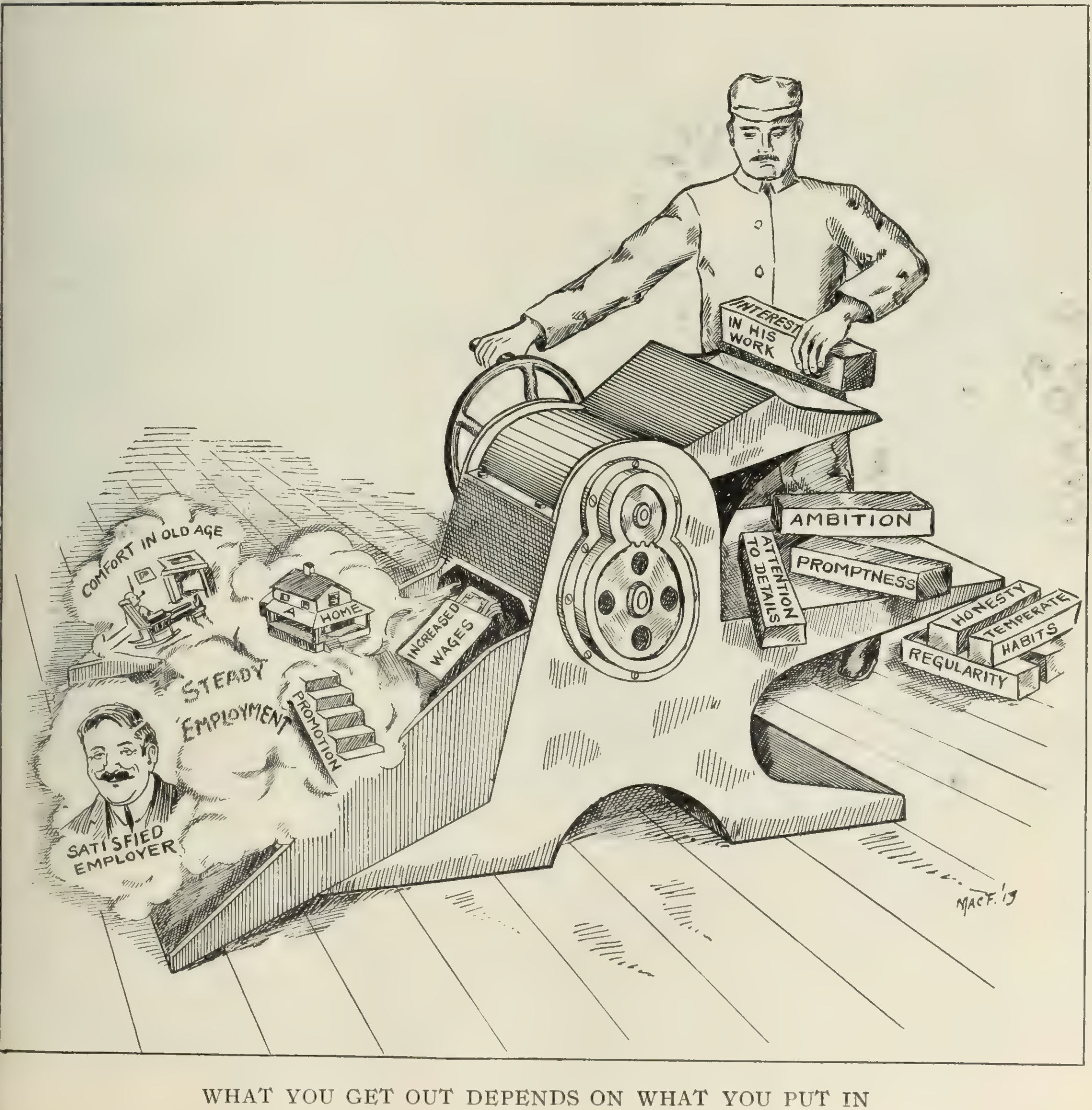
WILLIAM D. MARKS

William D. Marks, a well known consulting engineer, died at Plattsburg, N. Y., on Jan. 7. Prof. Marks was born in St. Louis, Feb. 26, 1849, and was graduated from Yale in 1870 with the degree of PhB. He specialized in civil and mechanical engineering and later received his C. E. degree from the same college. After leaving Yale he engaged in practical engineering work in connection with railways and gas and iron works. In 1876 he became instructor in mechanical engineering at the Lehigh University and the following year became associated with the University of Pennsylvania as Whitney professor in engineering. He was superintendent, in 1884, of the International Electrical Exhibition of the Franklin Institute, and later became engineer and president of the then Edison Electric Light Co., Philadelphia. Prof. Marks was an honorary life member of the Franklin Institute, a member of the American Institute of Electrical Engineers and a member of the American Philosophical Society. He was the author of several books and of many scientific papers and reports.

POWER

Vol. 39 NEW YORK, FEBRUARY 3, 1914 No. 5

The Mill of Life



WHAT YOU GET OUT DEPENDS ON WHAT YOU PUT IN

Plant of Worcester Salt Co.

By Charles H. Bromley

SYNOPSIS—Fresh water is pumped to wells leading to salt cavities in the earth, the water dissolves the salt and the brine is raised to the surface by air lifts. Bituminous slack is burned in the boilers, the coal being fed to the stokers by gravity from a suspended bunker 300 ft. long. Much exhaust and low-pressure steam is used for evaporating brine and drying salt.

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The power-plant man who has never seen a salt works in operation will find much to interest him in the plant of the Worcester Salt Co., at Silver Springs, N. Y.

In some salt regions, the product is mined, blasted out like rock in a quarry, but at Silver Springs it is dissolved by fresh water pumped into salt cavities in the earth. The aim is to obtain a brine of maximum saturation before raising it to the surface by air-water lifts. Fig. 1 shows two views of the works, the condenser water-cooling pond and the salt-well towers. Nature has eliminated the necessity of pumping the brine from the surface of the wells to the settlers seen at the edge of the pond in the top picture. The wells are on different levels and the brine flows by gravity in troughs leading to the settlers.

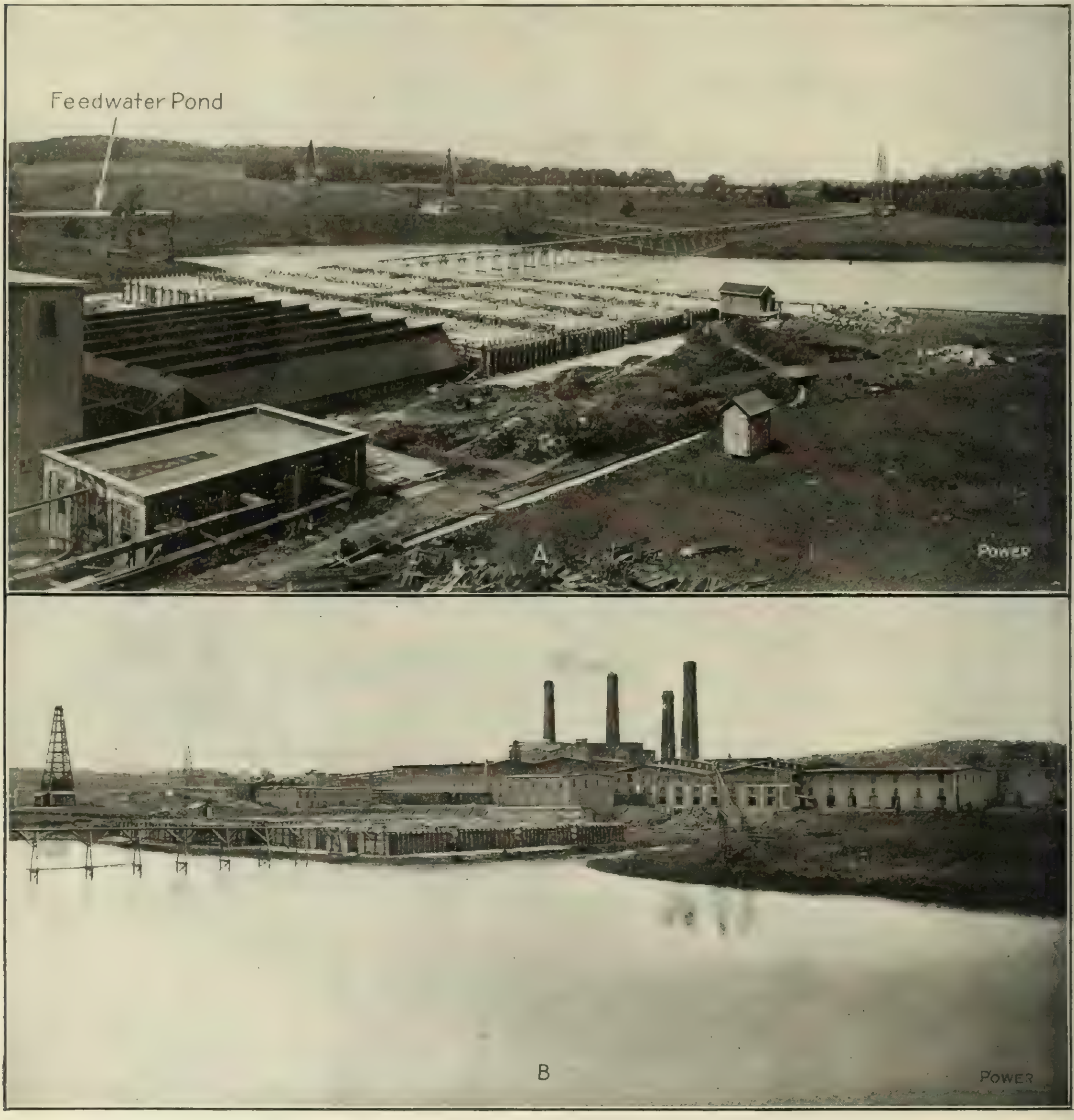

Fig. 1. (A) Feed-Water Pond, Salt Wells and Pump House; (B) Cooling Pond and Buildings

Boilers and Coal-Handling Equipment

As the brine taken from the wells must be evaporated, it will be realized that where 300 tons of salt is turned out daily, considerable steam is needed for evaporating and drying purposes. Steam is furnished by twenty-two horizontal tubular, stoker-fired boilers, fourteen of 200-hp. each and eight of 250 hp. each. Eight boilers are provided for high-pressure (115-lb.) service, three of which may be connected into the low-pressure (80-lb.) header; the others are used solely for furnishing steam at 80 lb. for heating and evaporating brine and for drying salt. Three boilers are kept in reserve to be used when the others are being cleaned or for emergencies.

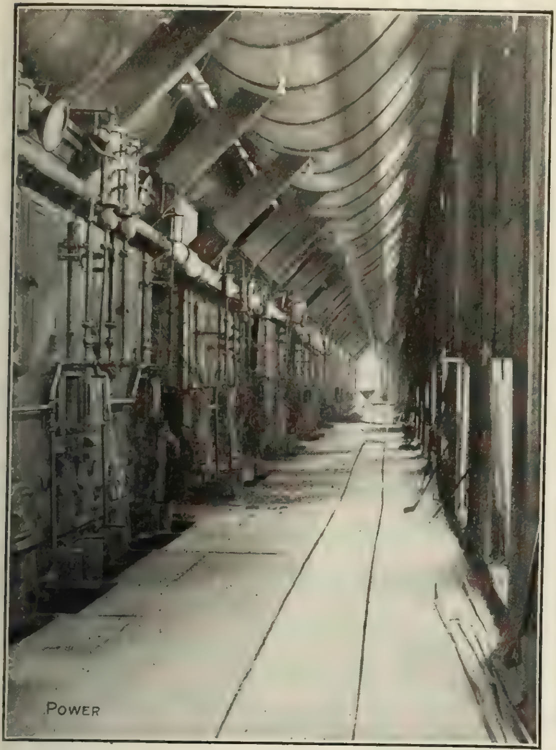

Fig. 2. Twenty-two Boilers; Suspended Coal Bunker 300 Ft. Long

A feature of the boiler house is the suspended coal bunker, Fig. 2, which is 300 ft. long and of 450 tons capacity. Bituminous slack is used as fuel and, as may be seen in Fig. 2, it must gravitate through the 8x13-in. rectangular chutes to the furnaces. Great as is the angle of inclination of these chutes, the slack will often stop in the chutes, especially if it is wet. This is a serious condition, owing to the little room available for making alterations.

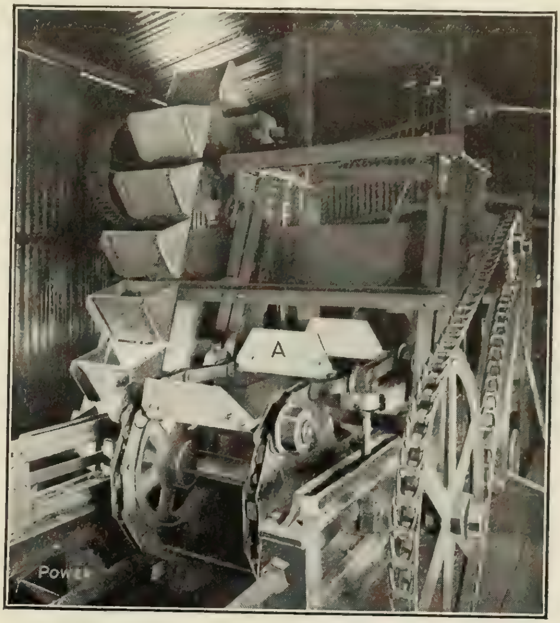

Fig. 3. View of Scraper and Bucket Conveyors

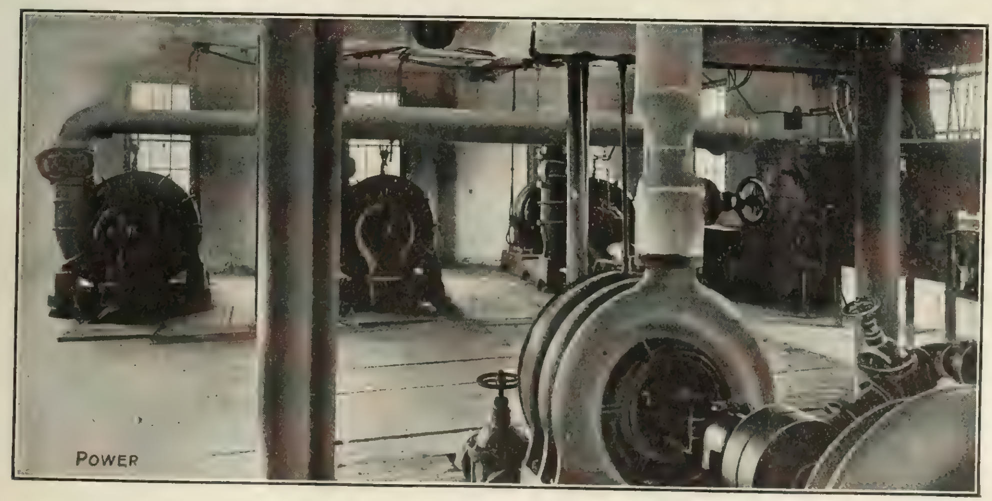

Fig. 4. Pump Room, All Pumps Motor-Driven, Centrifugal Type

Coal is dropped direct from cars into a hopper under the coal trestle. Then it is taken on an apron conveyor to the crusher and by a bucket conveyor is elevated to the scraper conveyor above the bunker. Parts of both conveyors are shown in Fig. 3. As indicated by Fig. 3, the coal is distributed over the bunker by a scraper conveyor which runs in a trough, the coal being pushed along by the plates A. Coal is dropped into the bunker by opening sliding gates in the bottom of the trough. Operation of the conveyor has shown that the forward end of the trough wears through before the other end manifests any signs of wear. This condition prevails because all coal must be pushed over the forward end, no matter in what part of the 300-ft. bunker it is to be dumped. Originally, the trough was of ¼-in. steel throughout, but to avoid service interruptions occasioned by frequently renewing the worn parts, the thickness of the trough has been graduated from ½ in. at the forward end to ¼ in. at other end. This has been done because by the time the front or thicker end will have worn through, the thinner end will also have worn out. Experience is showing that this result can be better accomplished by graduating the thickness from ¾ in. to ¼ in.

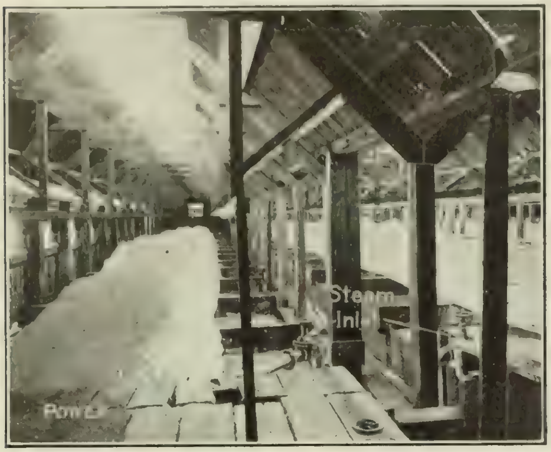

Fig. 5. Grainer Room Where Brine Is Evaporated at Atmospheric Pressure

The ashes drop from the stokers into large steel boxes in the ashpits, the boxes being lifted out by a crane traveling on the track in front of the boilers. Wedge-shaped steel side-dump cars receive the ashes, the cars being emptied in what the men term the "inferno," because the great pile of ashes burns continuously.

Feed-Water System

The boiler-feed water and the fresh water for salt making are supplied from a creek running through the property and from five driven wells. There are two ponds holding feed water and one large pond for cooling the 7,000,000-gal. 24-hr. consumption for the vacuum-pan condensers. About 1,000,000 gal. of fresh water is used daily, making a total of 8,000,000 gal. to be pumped. The fresh-water wells, like the salt wells, are on different levels, and after the water is raised by air, it gravitates to the ponds. Two motor-driven, single-stage centrifugal pumps in the pump house, shown in the left foreground of the top picture, Fig. 1, deliver water from the ponds to a filter and heater, from which it goes to a large open heater tank receiving the returns. Fig. 4 is an interior view of this pump house.

The feed pumps are in the engine room, about 30 ft. from the point where the feed lines enter the boiler room. Originally, a reciprocating feed pump was used but vibration of the line to the boiler room made it necessary to anchor the line with tie-rods and turnbuckles. A turbine-driven centrifugal pump was later installed in the engine room with a separate line to the boiler-room main. There is no vibration in this line.

Steam for Evaporating Brine

An idea of the amount of low-pressure and exhaust steam needed for salt making is had from the fact that the 15 grainers (one is shown in Fig. 5), have a capacity of 200,000 lb. of salt daily. The four vacuum pans, operating under 28 in. vacuum, turn out 425,000 lb. daily, making a total of 625,000 lb. of salt obtained by evaporating brine. Large heating tanks of 75,000 gal. capacity each and having coils of 3-in. pipe, preheat the brine evaporated in the vacuum pans. Besides the steam used for evaporating brine, much is employed in drying the salt prior to packing. The salt grains produced by the vacuum-pan process are much finer than those made in the open grainers.

Motor-driven centrifugal pumps handle the brine, which gives considerable trouble by corroding the pump impellers and casings. As the head is low, the leaks in the casings are sometimes temporarily stopped with wooden plugs. The air for lifting the well water, both fresh and salt, is furnished by a 175-hp. compressor delivering air at 400-lb. pressure to a receiver, the pressure being reduced at the receiver. Four 20-hp. reciprocating dry-vacuum pumps take air from the condensers serving the vacuum pans.

Electric-Generating Units

The two Corliss engines, of 250 and 150 hp. respectively, are connected by rope drives, with a line shaft to direct-current generators of 150 and 100 kw. capacity for reserve service, and one 450-hp. Corliss engine is directly connected to a 250-kw. direct-current generator for normal service. All the units are noncondensing, the steam being used for industrial purposes.

The energy is distributed by electric transmission to 55 motors ranging from 2 to 60 hp. The air in some of the rooms in salt works contains much salt which settles like dust. Many of the motors at the Worcester plant are in such rooms and, although no special casings are provided and the field-pieces and armatures are coated with salt, they give little trouble. The commutators and brushes are given considerable attention. The electrical department is equipped to make all the necessary repairs and renewals. A reciprocating fire pump of 1000 gal. per min. capacity is connected to the fire-line system. A gong and indicator in the engine room enable the engineer to tell when and what sprinkler head has opened.

A well equipped laboratory consisting in part of indicators, CO_2 apparatus, a coal calorimeter, crucibles and furnaces, water-analysis outfits, etc., is maintained in connection with the company's plant.

The duties of chief engineer are combined with those of the assistant superintendent, who is directly responsible for the operation and maintenance of the entire works.

PRINCIPAL EQUIPMENT OF THE WORCESTER SALT CO.'S PLANT, SILVER SPRINGS, N. Y.

No.	Equipment		Kind	Size	Use	Operating Conditions	Manufacturer
14	Boilers		Horizontal tubular	200 hp.	Low pressure steam	Stoker fired, 80 lb.	McEwan Bros.
8	Boilers		Horizontal tubular	250 hp.	High pressure steam	Stoker fired, 115 lb.	McEwan Bros
1	Engine	G	Corliss-single	24x36 in., 450 hp.	Main unit	100 lb., 120 r.p.m., direct connected	Allis-Chalmers
1	Engine	H	Corliss-single	16x38 in., 120 hp	Main reserve unit	100 lb., 85 r.p.m., rope drive	Watts-Campbell
1	Engine	I	Corliss-single	20x42 in., 200 hp	Main reserve unit	100 lb., 80 r.p.m., rope drive	C. & G. Cooper Co.
1	Air compressor		Steam driven, double	Steam end, 2-16x30 in., Air end, 2-8¼x18¼x30 in	Main air supply	100 lb., 75 r.p.m., 170 hp.	Air end: Ingersoll-Rand Co. Steam end: C. & G. Cooper Co.
1	Air compressor		Steam driven	Steam end: 20x24 in. Air end: 6¼x13¼x24 in	Main reserve air supply	100 lb., 165 r.p.m., 150 hp.	Norwalk Iron Works
1	Pump	J	Centrifugal	1-in., 2-stage	Boiler feed water	2750 r.p.m., turbine driven, 290 gal. p.m	Jeansville Iron Works
1	Pump		Reciprocating	14x13x8 in	Silos to filter to receiving tank	100 lb.	A. S. Cameron Steam Pump Co.
1	Pump		Reciprocating	2-18x10x12 in.	Fire mains	100 lb., 70 s.p.m., 1000 gal. per min	Worthington Steam Pump Co
1	Pump		Triplex	6x6½ in.	Pond to pond reserve	Motor driven	M. T. Davidson
2	Pumps	A	Centrifugal	10-in. volute	Brine to vacuum pans	Motor driven, single stage, 850 r.p.m	Worthington Steam Pump Co
1	Pump		Reciprocating	16x8x18 in.	Boiler feed water reserve	100 lb., 261 gal. per min.	A. S. Cameron Steam Pump Co
2	Pumps	B	Centrifugal	4-in. turbine	Brine to grainers	Motor driven, single stage, 1500 r.p.m.	DeLaval Steam Turbine Co.
1	Pump	C	Centrifugal	10-in. volute	Brine to vacuum pans	Motor driven, single stage, 850 r.p.m.	Worthington
1	Pump	D	Centrifugal	4-in. turbine	Water to salt cavities	Motor driven, single stage, 1100 r.p.m.	Worthington
2	Pumps	E	Centrifugal	4-in. turbine	Condensing water to vacuum pans	Motor driven, single stage, 1400 r.p.m.	Worthington
1	Pump	F	Centrifugal	6-in. turbine	Pond to pond (fresh)	Motor driven, single-stage, 1050 r.p.m	Worthington
1	Pump		Locomotive	8x8 in.	Sprinkler system	Intermittent	Westinghouse Air Brake Co.
4	Pumps		Reciprocating-vacuum	12x18x18 in.	Vacuum for pans	100 lb., 75 r.p.m., 50 hp.	A. S. Cameron Steam Pump Co.
22	Stokers		Overfeed	....	Boiler furnaces	Bituminous slack	Murphy Iron Works
1	Coal bunker		Suspended, steel-concrete	300 ft. long	Coal storage	Scraper-conveyor filled	Guarantee Construction Co.
1	Coal conveyor over bunker	K	Chain scraper convey.	300 ft. long	Coal transfer	Bituminous slack, motor driven	Guarantee Construction Co
1	Floor track trav. crane		Boom	Steel	Ash lift from pits	Motor driven	Northern Engineering Co.
1	Feedwater heater		Closed	6′ diam. x 13′ long.	....	Exhaust steam	Hoppes Mfg. Co.
1	Turbine	J	Impulse	2½″ steam	Boiler feed pump drive	100 lb., 2750 r.p.m., 56 hp., 290 gal. per min. at 300 ft. head	Terry Steam Turbine Co
2	Filters		Reversible	5′ diam. x 7′ high	Feedwater	....	
1	Generator	G	Direct current	300 kw.	Main unit	2500 amp., 120 volts, 120 r.p.m., direct connected	Allis-Chalmers Co.
1	Generator	I	Direct current	150 kw.	Main reserve unit	1200 amp., 125 volts., 500 r.p.m., rope drive	General Electric Co.
1	Generator	H	Direct current	96 kw.	Main reserve unit	800 amp., 120 volts, 600 r.p.m., rope drive	General Electric Co.
1	Switchboard		Direct control	7x10 feet	Main unit control	....	Worcester Salt Co.
1	Motor	K	Direct current	20 hp	Bucket, elevator and coal scraper conveyor	145 amp., 120 volts, 1100 r.p.m.	General Electric Co.
2	Motors	E	Direct current	40 hp.	Condensing water to vacuum pans	110 amp., 120 volts, 1400 r.p.m.	Allis-Chalmers Co.
1	Motor	D	Direct current	65 hp.	Fresh water to cavity	448 amp., 125 volts, 1100 r.p.m.	General Electric Co.
2	Motors	A	Direct current	60 hp.	Brine to vacuum pans	450 amp., 125 volts, 850 r.p.m.	Western Electric Co.
1	Motor	F	Direct current	7½ hp.	Pond to pond (fresh)	56 amp., 120 volts, 1050 r.p.m.	Sprague Electric Co.
2	Motors	B	Direct current	20 hp.	Brine to grainers	145 amp., 120 volts, 1500 r.p.m.	Diehl Mfg. Co.
1	Motor	C	Direct current	55 hp.	Brine to vacuum pans	420 amp., 110 volts, 845 r.p.m.	General Electric Co.
1	Apron conveyor	L	Trestle hopper to coal crusher	....	....	....	Guarantee Construction Co
1	Bucket elev.	K	Coal crusher to scraper conveyor	....	....	....	Guarantee Construction Co.
1	Motor	L	Direct current	20 hp.	Coal crusher, apron conveyor and car puller	148 amp., 115 volts, 1100 r.p.m.	Sprague Electric Co.

Note:—Letters A and A, B and B, C and C, etc., indicate connected units.

Properties of Ammonia*

Ammonia, so called, because originally prepared from camels' dung, near the temple of Ammon, in Egypt, is a compound of hydrogen and nitrogen, having the chemical formula NH_3, which means that an atom of nitrogen (representing 14 parts by weight) is combined with three atoms of hydrogen (representing three parts by weight.) It is a colorless gas at ordinary temperatures and pressures, but at about —27 deg. F. it becomes liquid at the pressure of the atmosphere, and, of course, at higher temperatures if greater pressures are employed.

At about —110 deg. F., liquid ammonia turns into a white crystalline solid, and is almost without smell; at about 900 deg. F., ammonia dissociates—that is, it is decomposed into its constituents, nitrogen and hydrogen.

Ammonia gas is very soluble in water, the solution constituting the so called aqua ammonia that is employed in absorption systems. The capacity of water for absorbing ammonia gas varies with its temperature, but ordinarily it will take up from 500 to 800 times its own volume.

Following its discovery by an ancient alchemist, ammonia was in time manufactured through the destructive distillation of horns, hoofs, and hides, and its production from horns gave an early name to aqua ammonia of "spirits of hartshorn." Now ammonia is chiefly obtained as a byproduct in the manufacture of illuminating gas from coal and from the manufacture of coke in byproduct coke ovens.

Lately, the production of ammonia synthetically, using the nitrogen of the atmosphere, has engaged the attention of scientists. It is very doubtful, however, that the successful commercial production of synthetic anhydrous ammonia has yet been achieved. The anhydrous ammonia produced carries suspended in it uncombined nitrogen and hydrogen gases, and the cost of manufacture is probably greater than by the usual method. There is practically an unlimited demand for sulphate of ammonia as an agricultural fertilizer, and the synthetic manufacturers have this product immediately in mind rather than anhydrous and aqua ammonia for employment in refrigeration and ice-making.

Experienced operating refrigerating engineers know the desirability of employing in plants under their charge anhydrous ammonia that is free from uncombined nitrogen or hydrogen gases, which occupy condenser space that should be occupied only by ammonia gas, and being present, give rise to abnormal working pressures and impose the need of frequent purging to expel them.

Anhydrous ammonia, by reason of its adaptability to liquefy under comparatively low pressures, is the medium most generally employed in refrigerating and ice-making machines. As an indication of the growth of the industry it may be stated that in 1890, there were not more than 1000 ammonia-using refrigerating and ice-making plants in operation in the United States. At the present time there are at least 12,500 plants, while the increase of like plants in foreign countries, though not as rapid as in the United States, exhibits a healthy growth.

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*Abstract of paper read by J. C. Atwood before the Practical Refrigerating Engineers' Association, Dallas, Tex.

Cost of Compressing Air by Electricity

By W. C. Lancaster

SYNOPSIS—Factors in determining the relative costs of compressing air by steam and by electricity. The figures for the latter are based on actual installations where a low rate for electricity is charged. The article applies chiefly to compressor plants used in construction work, where there are limitations of space, where the work is more or less of a temporary nature and where there is no use for exhaust steam.

⁂

The increase in the use of electricity as a motive power during the past decade has been the cause of marked improvement in air-compressor construction. During this period there has been a constantly increasing demand for large compressors which has resulted in the development of the modern high-speed, direct-connected electrically driven air compressors that are being used so universally at present.

Cheaper rates for electric power quoted by central stations and the saving in space effected by motor-driven compressors are largely responsible. A striking example

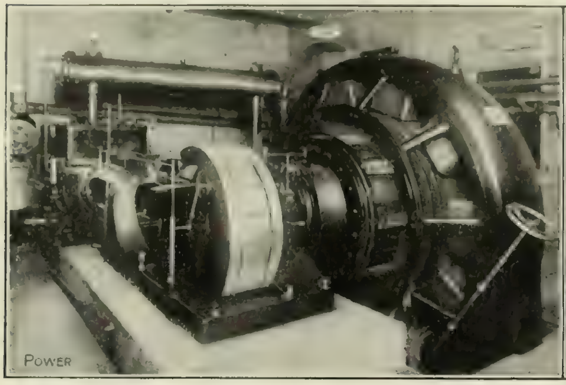

FIG. 1. MOTOR-DRIVEN COMPRESSOR USED IN CONNECTION WITH PENNSYLVANIA R.R. TUNNELS

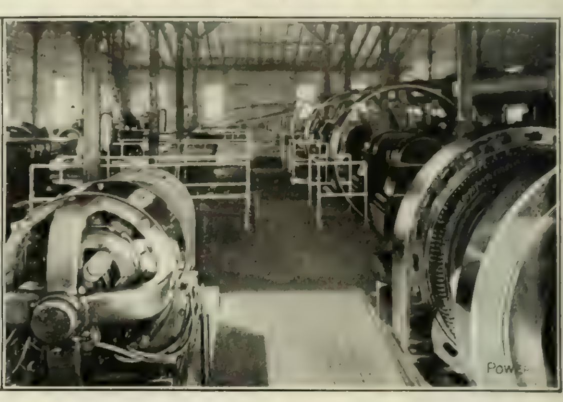

FIG. 3. BELTED COMPRESSORS REFERRED TO IN "E," TABLE 1

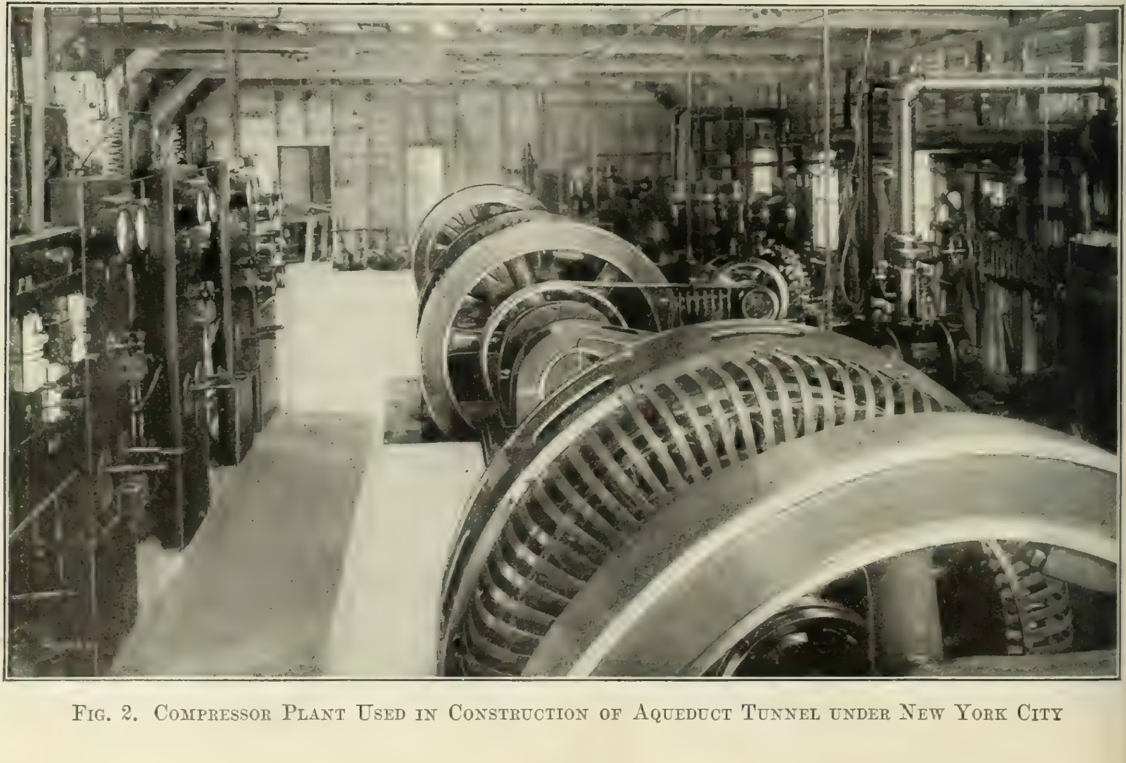

FIG. 2. COMPRESSOR PLANT USED IN CONSTRUCTION OF AQUEDUCT TUNNEL UNDER NEW YORK CITY

of both of these is the plant installed by the writer in 1905 in connection with the construction of the Pennsylvania R.R. crosstown tunnels in New York City. This plant, a part of which is illustrated in Fig. 1, was located within one block of the Waldorf-Astoria. Property in this neighborhood was so expensive that the elimination of space for steam boilers and for the storage of coal was a necessity. Even with a high rate for electricity it would undoubtedly have figured less expensive to use electric compressors, but as a matter of fact a most attractive rate was obtainable from the New York Edison Co.

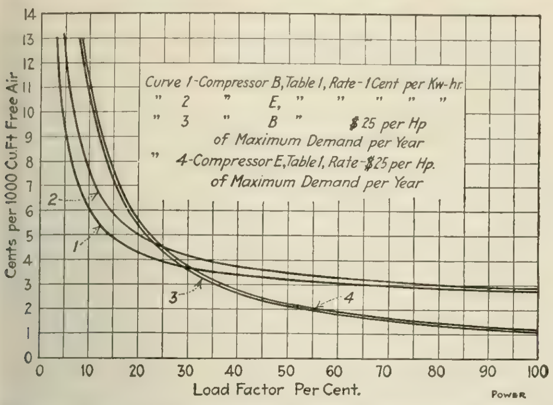

FIG. 4. COST OF ELECTRICITY FOR COMPRESSING AIR AT DIFFERENT LOAD FACTORS

Other examples of the use of electric compressors where space is limited are the plants used for the construction of the Catskill Aqueduct under the City of New York. The contracts for this work required the use of electricity wherever possible in order to do away with the noise and dirt incident to steam plants; besides this, the space furnished the contractors around each shaft for the plant was so limited that electric-driven compressors had to be used in almost every case. One of these plants, also installed by the writer, is illustrated in Fig. 2.

The first air compressors to be driven by electricity were either belted or geared to the motor. This drive is still used for compressors of small size and also for the larger sizes where electric power is cheap, or where the installation is only temporary. Sometimes even for air plants on construction work that will be completed in two to three years, it pays when the rate charged for electric power is high, to use the more expensive direct-connected machines.

The question of whether an air-compressor plant had better be operated by steam or electricity depends upon so many variables that it is impossible to give a general rule to cover all cases. Each must be worked out individually, taking all the local conditions into careful consideration and balancing the first cost and operating cost of each, comparing the steam and electric operation about as follows:

Steam	Electric
First cost:	
Compressors and engines	Compressors and motors
Boilers	
Stokers	
Economizers	
Feed-water heaters	
Condensers	
Pumps	
Compressed-air piping	Compressed-air piping
Steam piping	
Cooling-water piping, pump and tanks	Cooling-water piping, pump and tanks
Coal-handling machinery	
Coal-storage bunkers	
Ash-removal machinery	
Building and foundations	Building and foundations
Stack or mechanical draft	
Land	Land
Operating cost:	
Fixed charges, including interest, taxes, insurance and depreciation	Fixed charges, including interest, taxes, insurance and depreciation
Coal for operating compressors and auxiliaries	Electricity for operating compressors
Coal for heating building	Coal for heating building
Coal handling	
Ash removal	
Water for boilers	
Water for condensers	
Water for compressor jackets	Water for compressor jackets
Oil for air cylinders	Oil for air cylinders
Oil for steam cylinders	
Oil for guides and pistons (and crankshaft if cross-compound)	Oil for guides, pistons and crankshaft bearings (same as motor bearings if direct connected cross-compound)
Waste	Waste
Repairs	Repairs
Labor in compressor room	Labor in compressor room
Labor in boiler room	

In figuring the cost, of course, the type of plant must be chosen that seems to best suit the conditions of the problem in hand. For steam the principal questions to

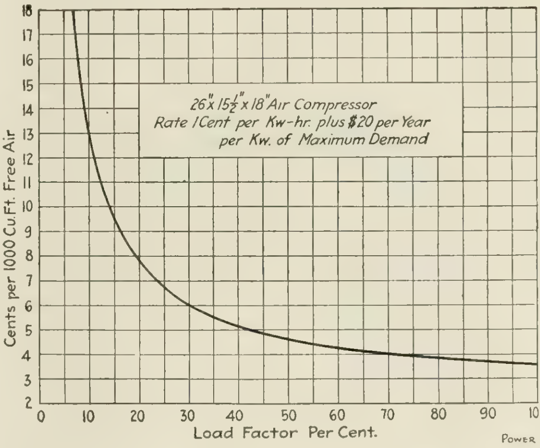

FIG. 5. COST OF ELECTRICITY FOR COMPRESSING 1000 CU.FT. OF FREE AIR AT DIFFERENT LOAD FACTORS—COMPRESSOR C, TABLE I

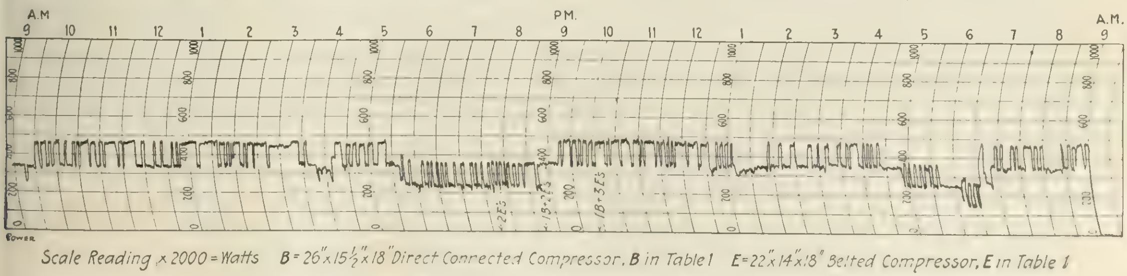

FIG. 6. LOAD CHART OF TYPICAL 24-HR. RUN

be decided are whether the plant is to be condensing or noncondensing, and whether the compressors are to be of the simple steam, compound-air type, or the compound-steam, compound-air type. For the electric plant the main point to be decided is whether the compressors are to be belt driven or directly connected to the motors.

Estimates of the first cost of both steam and electric compressor plants are easily computed, and so many steam plants have been installed that both their first cost and operating cost have been carefully worked out and are very well known to engineers and contractors who have to do with plants of this nature.

But as regards the cost of electric power required to deliver a given amount of compressed air, there seems to be some uncertainty as well as a considerable lack of published data on the subject.

In the Jan. 6, 1914, issue of POWER, the writer gave a method of testing electric-driven air compressors and the results of a test on a large unit. Some similar test results are given in Table 1.

TABLE 1 AIR-COMPRESSOR TESTS

Compressor	Size	Speed r.p.m.	Piston Displacement Cu Ft per Min.	Discharge Air Pressure Lb per Sq In.	Volumetric Efficiency Per Cent	Horsepower Input per 100 Cu Ft per Min Free Air	Kilowatt-hours per 1000 cu ft. of Free Air	Horsepower Input No Load	Drive
A	26x15½x18	185.5	2042.5	100	85.1	22.85	2.85	53.1	Direct-connected
B	26x15½x18	185.3	2039.7	100	86.5	22.75	2.83	51.0	Direct-connected
C	26x15½x18	188	2070	100	88.0	23.26	2.91	56.6	Direct-connected
D	25¼x15¼x21	188	2117	100	79.2	23.89	2.99	60.3	Direct-connected
E	22x14x18	157.8	1241.2	100	88.6	23.7	2.94	46.0	Belted

It will be noted that the first three machines are of the same size. They are also of the same type and the volumetric efficiencies and other characteristics check very closely.

Compressor D is of very nearly the same size and speed as the first three, but is of a different type and driven by a different make of electric motor, either or both of which facts may account for its lower volumetric efficiency and somewhat greater input per 100 cu.ft. per min. of free air.

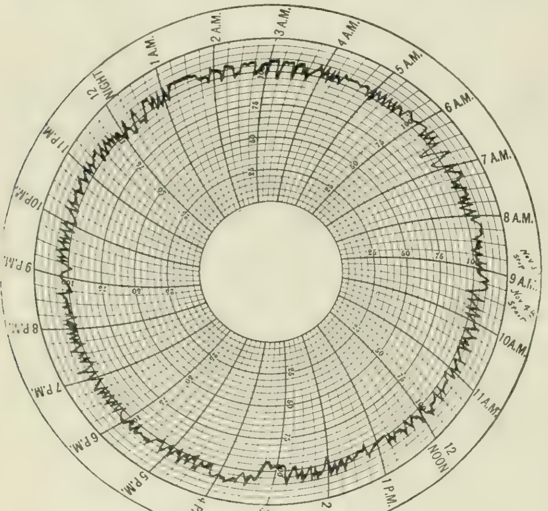

FIG. 7. PRESSURE CHART

The speed of compressor E is lower and this undoubtedly accounts for its higher volumetric efficiency. Being a considerably smaller machine this efficiency would probably be somewhat lower if the speed were the same as the others. Although belt-driven, the economy as regards electric power input per 100 cu.ft. of air is very little higher than the larger direct-connected machines. This is partly due to the higher volumetric efficiency and partly to the exceptionally good belt drive. The belt is wide and heavy and there is ample distance between driving and driven pulleys, so that there is probably very little power lost. Four of these belted compressors and motors are shown in Fig. 3.

The cost of electricity for compressing air depends on three things:

1. The power input per cubic foot of air output required by the compressors, or "power efficiency" as it might be called.
2. The load factor of the plant.
3. The rate charged for electricity.

The first of these, or the "power efficiency," has already been discussed. In making an estimate of the cost of electric power for a given plant a value for this power efficiency must be assumed, and this can be based either on test data similar to that given in Table 1, or upon the guarantee of a reliable manufacturer. Care must be taken in selecting this value that the test or guarantee from which it is obtained is on a compressor of exactly or very nearly the same size, type and speed, as a considerable difference in any of these will sometimes change the power efficiency materially.

By "load factor" is meant the ratio of the actual output of compressed air from the plant in a given period of time, to the total output that the plant is capable of making in that time. The effect on the energy required to do useful work is evident when it is remembered that electrically driven air compressors unlike those driven by steam, run at constant speed whether loaded or unloaded and therefore the energy required during the time they are running unloaded and doing no useful work adds more and more to the energy input per cubic foot of air output as the load factor decreases. This effect on the economy of operation is small except at very low load factors, as can be noted from Figs. 4 and 5.

It is rather difficult to predict in advance just what this load factor will be. The best way to arrive at it is perhaps to compare the plant under consideration with other plants already built which are doing similar work and whose load factors are known.

In well designed plants furnishing compressed air for rock drills, pumps, etc., where the work is carried on day and night, the writer has found that the load factor usually runs well over 50 per cent., in some cases even reaching 80 per cent. For instance, the load curve given in Fig. 6 is a typical 24-hr. run taken in the plant illustrated in Fig. 3. The load factor for this run figures 78½ per cent.

The rate charged for electricity has the most important bearing of all upon the operating cost of electrically driven air compressors. These rates vary in different localities between rather wide limits. Usually the rate is either so many cents per kilowatt-hour; so many dollars per horsepower (or kilowatt) of maximum demand per year; or some combination of these two.

To illustrate the effect of the power efficiency, load factor and rate on the cost of power, curves have been worked out with load factor as abscissas and cost of compressed air as ordinates. Curve 1, Fig. 4, shows how the cost for electric power per 1000 cu.ft. of free air, compressed to 100 lb. gage by compressor B, Table 1, varies with the load factor when the rate for electric power is 1c. per kw.-hr. This curve is figured as follows:

Compressor capacity = 1764.75 cu.ft. per min
Yearly output = 1764.75 × 365 × 24 × 60 = 927,553,600 cu.ft. per yr.
Compressor input = 299.5 kw
Kw.-hr. per year = 299.5 × 8760 = 2,623,620
At 1c. per kw.-hr., yearly cost = $26,236.20
Cost per 1000 cu.ft. = $26,236.20 ÷ 927,553.6 = $0.0283

This is at 100 per cent. load factor. Values at other load factors are obtained from the equation,

$$x = \frac{26{,}236.20\,y + 3328.8\,(1.00 - y)}{927{,}553.6\,y}$$

where

x = Cost in dollars per 1000 cu.ft.;
y = Load factor expressed as a decimal.

The second term of the numerator is the cost when the compressor is running idle. With the input at no load, equal to 38 kw., the yearly cost at no load would be

$$38 \times 8760 \times 0.01 = 3328.80$$

and during the actual no-load period would be

$$3328.8 \times (1.00 - y)$$

The other curves in Fig. 4 are drawn in a similar way. Curve 2 is for a 22x14x18-in. belted compressor (E in Table 1) with the same rate for power.

Curves 3 and 4 are for the same machines, but are based on a rate for electric power of $25 per hp. of maximum demand per year. It will be noted that at low load factors the 1c. rate is better, but not so good at the higher load factors.

The rate for power paid by the contractors who are building the sections of the Catskill Aqueduct under the City of New York is 1c. per kw.-hr. plus $20 per year per kilowatt of maximum demand. The curve in Fig. 5 is worked out on this basis. It is figured from the results of a test on one of the three compressors shown in Fig. 2 (compressor C, Table 1).

In order to give some idea of the total cost of compressing air the plant illustrated in Fig. 3 will be used as an example. Cost figures are given in Table 2. This plant consists of four 22x14x18-in., two-stage, cross-compound compressors belt driven by induction motors, and one 26x15½x18-in. compressor of the same type, but direct connected to a synchronous motor. The belted machines are each rated at 1240 cu.ft. per min. displacement, and the direct-connected machine at 2040 cu.ft. per min. One of the small compressors is held in reserve as a spare, so that the maximum number run at one time consists of the large machine and three small ones. Thus the total rated displacement of the plant is 5760 cu.ft. of free air per min. From the test results the actual total output is 5065 cu.ft. of free air per minute.

This plant is in Canada at the West Portal of the tunnel now under construction for the Canadian Northern R.R. and has been in operation about 16 months. The compressors were manufactured in the United States and a high duty had to be paid on them. The first cost given in Table 2 for the plant is therefore high compared with a similar plant in the United States. The figures for water, wages, supplies and repairs are the averages for the five months from June to October, inclusive.

The actual rate paid for electric power for this plant is rather complicated and would not serve as an illustration as well as a straight meter rate. An assumed rate of 1c. per kw.-hr. has therefore been used.

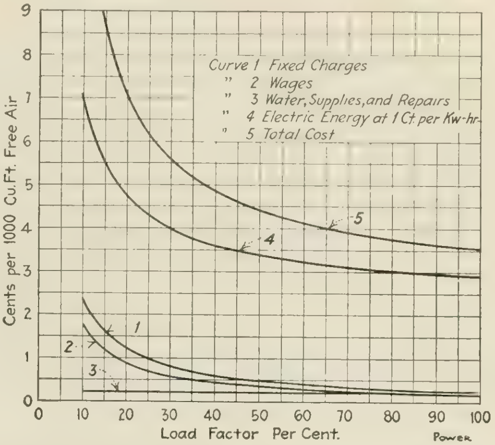

FIG. 8. TOTAL COST OF COMPRESSING 1000 CU.FT. OF FREE AIR AT DIFFERENT LOAD FACTORS—PLANT IN TABLE 2

A typical 24-hr. run is shown in Fig. 6. This chart was taken by means of a recording wattmeter connected so that the total power input to all the compressors was recorded. The maximum input is 924 kw. and the average 724 kw. The load factor for this day is therefore 78½ per cent. The pressure chart in Fig. 7 was taken at the same time that the load curve of Fig. 6 was made and shows an average pressure for the 24 hr. of 107 lb.

TABLE 2.

		Cost
First Cost—		
Cost of the five compressors, including motors and switchboard		$31,000
Piping, aftercooler and air receiver		3,000
Building and foundations (land not included)		2,700
Installing		2,300
Total		$39,000
Yearly Cost—		
Fixed charges—		
Interest on investment $39,000 × 6% =	$2340	
Taxes, 1% on land and building	200	
Insurance @ 20c. per $100 per year	78	
Depreciation, at 10% per year	3900	
Total yearly fixed charges		$6518
Operating charges—		
Power on basis of load curve of Fig. 6, giving load factor of 78½%.		$63,422
Water, average daily consumption 7000 cu.ft., or $200 per mo. @ 10c. per 100 cu.ft.		2,400
Wages, average $400 per mo. for three 8-hr. shifts		4,800
Supplies, such as oil, waste, etc., average per month $103		1,236
Repairs, average per month, $49		588
Total operating charges		72,446
Total yearly cost		$78,964

The curves in Fig. 8 have been worked out to show how the total cost per 1000 cu.ft. of air varies with the load factor for the plant under consideration. Curve 1 shows the fixed charges. It is figured simply by dividing $6518 by the yearly output at the different load factors in thousands of cubic feet of free air. Curve 2 is similarly figured for wages only. The cost of water, supplies and repairs is assumed to vary in proportion to the load factor and therefore the cost of these items per 1000 cu.ft. of air is constant, as can be seen from Curve 3.

The cost for electric power based on a rate of 1c. per kw.-hr. is given by Curve 4. At low load factors this is slightly higher than would actually be the case in practice as the compressors would be shut down one after another as the load factor decreased instead of being run for any length of time at no load. For these calculations, however, in order to avoid breaks in the curve, the whole plant has been treated as though it consisted of one machine of the average economy of the four.

The total cost of 1000 cu.ft. of free air compressed to 107 lb. per sq.in. in this plant at various load factors is given in Curve 5, which is the sum of the ordinates of all the other curves, 1 to 4 inclusive.

* * *

Oil-Burning-Furnace Design

By J. J. McIntosh

SYNOPSIS—The omission of checker work and target walls is recommended. A number of furnaces applied to different boilers are illustrated.

* * *

The most important feature of an oil-burning system is the furnace arrangement. Poor economy is often due to improper furnace conditions, and upon the design of the furnace depends to a great extent the capacity of the boiler. If the furnace design is correct a 200 per cent. overload can be carried without injuring the boiler. The practice of using firebrick arches, checker work, target walls, etc., is unnecessary and is frequently the cause of the burning out of tubes or bagging the boiler. With such arrangements the cost of furnace repairs becomes high and they are likewise the cause of interruptions in service. The furnace should be designed so that the flame will not impinge on either the boiler or brickwork. The disastrous effects of the blowpipe action of the oil flame on the metal of boilers has become well known to engineers, but unfortunately many found it out too late. To secure the best results for burning oil, the furnace must be so arranged that, first, all air must pass through the flame; secondly, that the atomized oil must be completely burned while suspended in the air; third, that a large surface of brickwork be exposed near the flame; and, fourth, the flame must be distributed over a large area.

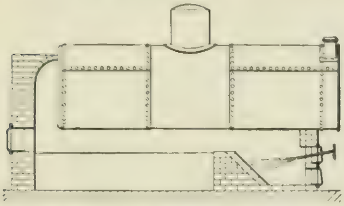

Fig. 1. Tubular Boiler with Target

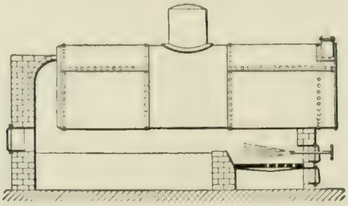

Fig. 2. Another Furnace Open to Objection

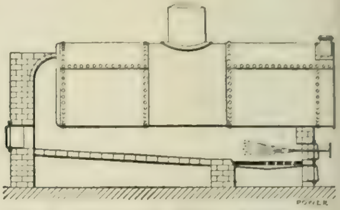

Fig. 3. Furnace Well Adapted for Tubular Boiler

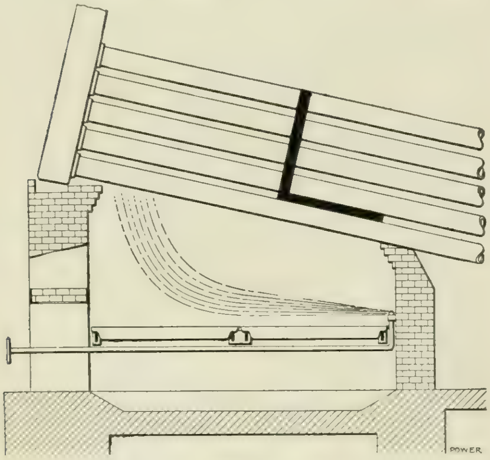

Fig. 4. Peabody Burner for B. & W. Boiler

Before going further, it might be well to state that the melting out of firebrick in an oil furnace may not always be caused by the heat alone, but is sometimes due to certain agents present in some oils which cause a fluxing action and melt the brick in a short time.

Fig. 1 shows a return-tubular boiler with the furnace arranged with a target. As was stated above, this type of oil furnace is liable to injure the boiler.

Fig. 2 is another arrangement of oil furnace for a return-tubular boiler. Although this type of furnace is still used to a certain extent, it is open to the same objections as the arrangement in Fig. 1, especially when

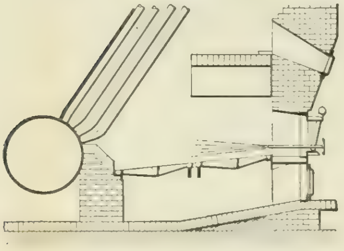

Fig. 5. Furnace Often Used with Stirling Boiler

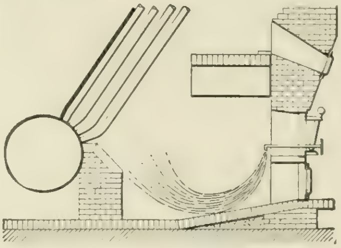

Fig. 6. Down-Shot Furnace for Stirling Boiler

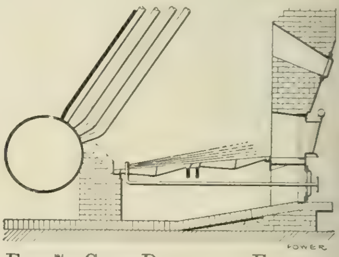

Fig. 7. Good Design of Furnace for Stirling Boiler

he boiler is forced. This brings to mind the case of a lant using four return-tubular boilers fired with oil and ising a furnace arranged as in Fig. 2. In less than two nonths after changing from coal to oil the plant had to e shut down to repair the boilers.

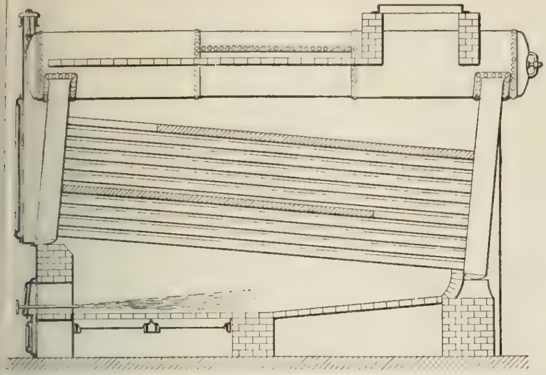

Fig. 8. Furnace in Edge Moor Boiler

Practice has demonstrated the design of furnace shown in Fig. 3 to be well adapted for burning oil under this type of boiler.

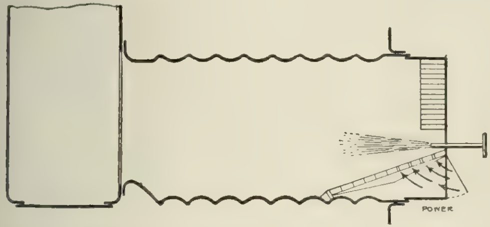

Fig. 10. Furnace in Scotch Marine Boiler Using Fishtail Burner

Fig. 4 illustrates a Babcock & Wilcox boiler fitted with a Peabody oil furnace. The furnace is fired from the bridge-wall forward, but is controlled from the boiler front and is commonly termed the "forward-shot" furnace. This arrangement of oil furnace has given excellent results.

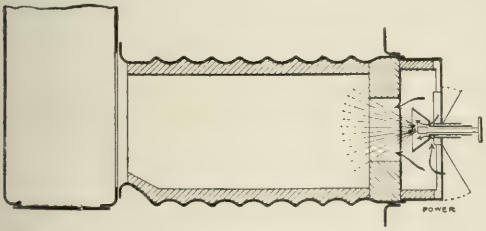

Fig. 11. Scotch Marine Boiler Equipped with Mechanical Burner

Fig. 5 shows a Stirling boiler with a furnace for oil that is used to a considerable extent. It is open to the objection that under heavy loads the flame is liable to impinge directly against the tubes. In Fig. 6 is shown a "down-shot" type of oil furnace with a Stirling boiler.

Fig. 7 is probably the best design of oil furnace for this type of boiler. It is, of course, understood that with this type of furnace the lining of the front is heavily reinforced with firebrick.

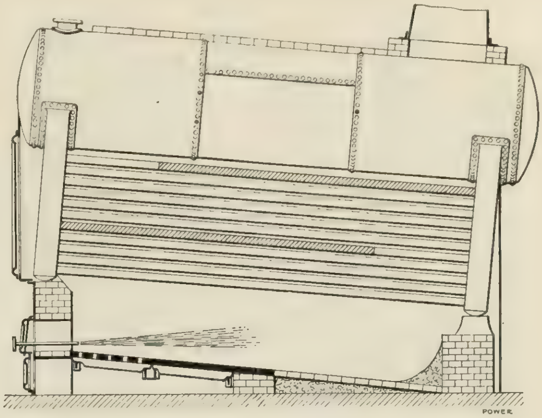

Fig. 9. Risdon Boiler Equipped for Oil Burning

Figs. 8 and 9 illustrate Edge-Moor and Risdon water-tube boilers of the horizontal-pass type, fitted up for burning oil. In boilers of this make with a cross-pass setting, the correct furnace arrangement would be one similar to that applied to the Babcock & Wilcox boiler shown in Fig. 4.

In Fig. 10 is shown the furnace arrangement of a Scotch marine boiler using a fish-tail burner.

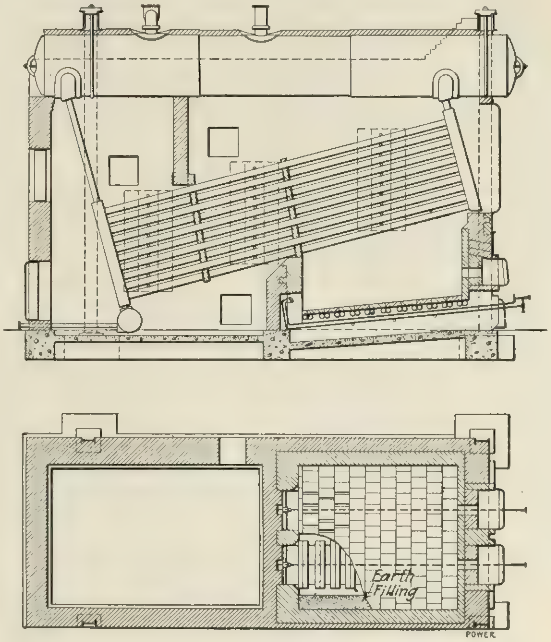

Fig. 12. Hammel Burner and B. & W. Boiler

Fig. 11 illustrates the same type of boiler using a mechanical burner producing a round flame. Using the arrangement shown, the mechanical burner with a round flame gives excellent results.

Figs. 12 and 13 illustrate the Hammel oil-burning furnace as applied to the Babcock & Wilcox and Stirling water-tube boilers. In the construction of this furnace each burner has an independent air supply. With a boiler using two or more burners, it is possible with this furnace to completely cut off the air supply to any burner that may be extinguished due to load conditions or for standby service, and not interfere with the burner or burners in operation.

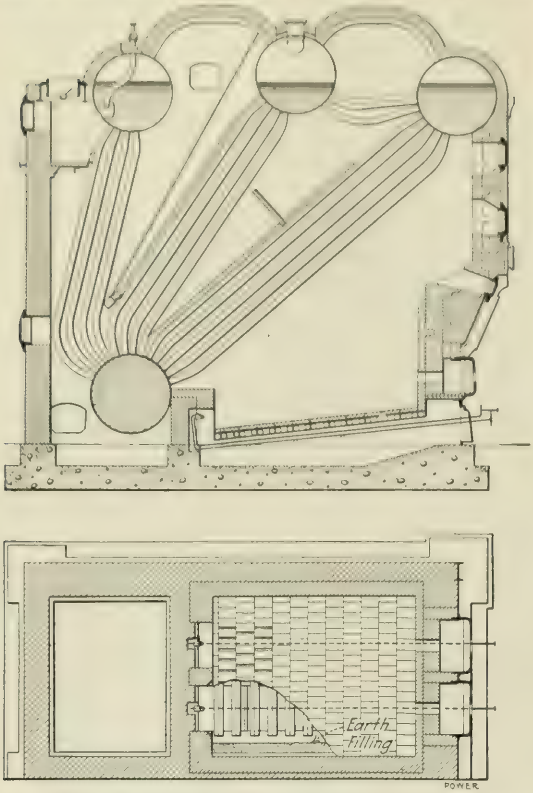

Fig. 13. Stirling Boiler Equipped with Hammel Burner

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Undesirable Power-Plant Conditions

By C. O. Sandstrom

Probably no power plant in this country, in design and equipment, is above honest criticism, and the designing engineer being human, and consequently fallible, commits errors of judgment which are sometimes supplemented by errors of information. Of course, these things are found less frequently in the larger plants, because the expenditure of a large sum of money justifies and necessitates the services of competent engineers.

Last summer the writer studied the design of a manufacturing plant in the Middle West, which for monstrosities was a veritable chamber of horrors, and, as an educational factor, was in the first rank. The power plant contains six 410-hp. water-tube boilers and two 800-kw. generators, driven by cross-compound condensing Corliss engines.

At first sight, this plant appears to be of usual design, but a superficial examination discloses details that render it a failure from an operating standpoint. When the plant was built, about six years ago, there were installed three boilers and one generator, but the boiler plant did not take care of the load and a fourth boiler was installed. Later, when the second generator was put in, two more boilers were added. Although but one generator was run at capacity, the behavior of the boiler plant indicated that if both generators were operated, the boiler capacity would be inadequate.

The condensing equipment consists of two siphon condensers (the injection inlets are about 45 ft. above the hotwell) served from a cross-connection in the piping by a 10 and 14 by 10-in. duplex steam pump. This pump, located about 500 ft. from the power house, took its water through some 300 ft. of pipe from a pond, the total head being about 70 ft. The exhaust was allowed to escape to the atmosphere. In times of high-temperature circulating-water, when full load came on the engine, the water required was above the capacity of the pump, and frequently the engine was operated on an 18-in. vacuum.

The feed-water heater, of the open type, would probably handle 500 hp. It was foisted upon the concern by a salesman who asserted that it was capable of heating the feed water for 1200 boiler horsepower. No one being the wiser, it was installed, and the trouble began. The exhaust from the auxiliaries was led to the heater, and in an attempt to raise the feed-water temperature above 130 deg. (which seemed to be the limit) by using all the exhaust from the exciter engine, large quantities of steam and water were blown out to the air.

In the suction line from the heater to the boiler-feed pump is a check valve for which the present engineer could find no use, so he removed the disk, thus eliminating a restriction to the flow. The 18-in. steam header is back of the double-drum boilers, which are connected to the header by 5-in. branches, one to each drum. There is a stop valve in each branch at the boiler nozzles. About 30 ft. of one end of the header has never been covered, and the heat loss, added to that from the remainder of so large a header, has been considerable, as was evidenced by the continual working of the traps.

The boiler-feed main terminates at one end of the row of boilers in a manifold, the branches running down behind the boilers in a confusion of piping.

The three boilers originally installed were connected to an 8x100-ft., guyed, steel stack, by a 6x3-ft. brick-lined underground flue. Owing to the insufficient height of the stack, aggravated by the small flue area, the boilers could not be run to their capacity, but if a test had been run, the cause of the trouble might have been ascertained. Instead, another boiler was installed which, of course, did not improve the draft conditions.

When the fifth and sixth boilers were added, they were connected to a flue running parallel with the old one and between the first boiler; and the stack was brought into the old flue at right angles. This resulted in more than 2400 boiler horsepower, connected to an 8x100-ft. stack by a 6x3-ft. flue.

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Lighting Contract for Portland—The Portland Railway, Light & Power Co., after competitive bidding, has been awarded a contract for lighting the streets of Portland, Ore., for a period of three years beginning Jan. 1, 1914. The company recently completed the installation of a 10,000-hp. turbine, giving a total generating capacity of 90,000 hp. Twelve cities and towns in Oregon and Washington, having a total population of approximately 300,000, are now being supplied by the company.

Solving the Cinder Problem at Waterside—II

By Charles H. Bromley

SYNOPSIS—This second article in the series describes the original boiler-flue arrangement at Waterside Station No. 2. An average of 2000 tons of coal is burned daily on a ground area of 600x300 ft. A sawtoothed-shaped screen swept with air brushes passes through the base of the stack to intercept the cinder.

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ORIGINAL FLUE ARRANGEMENT AT WATERSIDE

At Waterside No. 2 station, where nearly all the experimental cinder-catching apparatus was tried out, there are 96 boilers of 650 hp. each on two floors, 48 boilers to a floor, each floor having eight horizontal flues, each 50 ft. long by 9 ft. wide and receiving the gases from six boilers placed back to back, three in a row. There are four steel smokestacks, each 264 ft. in height above the grates of the boilers on the second floor. The stacks were made 100 ft. higher than those at Waterside No. 1, chiefly to discharge the cinder high enough for the prevailing northwest winds, which blow for 33 per cent. of the time at that place, to carry most of the cinder above the East River before it could settle.

2000 TONS BURNED DAILY IN SPACE 600x300 FT.

Waterside No. 1 station has 54 boilers on two floors, 28 on the first floor and 26 on the second. Usually there are 90 boilers in service and standing-by in both stations at all times.

The daily average coal consumption for both plants is 2000 tons. As in all central stations, severe load fluctuations must be cared for. A few of the storm peaks were shown in Figs. 2 and 3 of the issue of Jan. 27.

Think of it! An average of 2000 tons of coal per day burned on an area approximately 600x300 ft., and located in a congested part of Manhattan. No wonder the

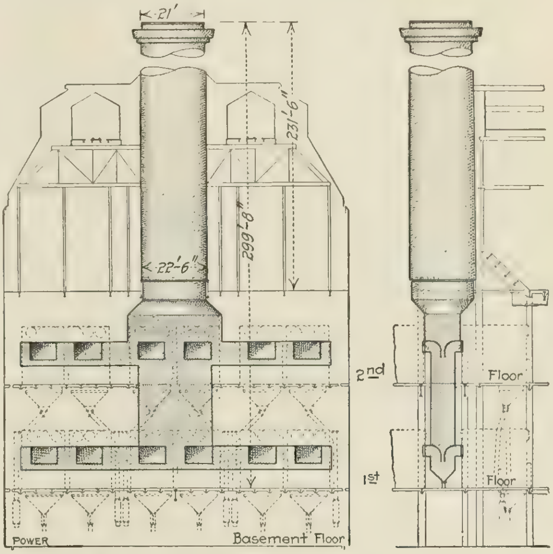

FIG. 5. ORIGINAL ARRANGEMENT OF FLUES AT WATERSIDE STATION

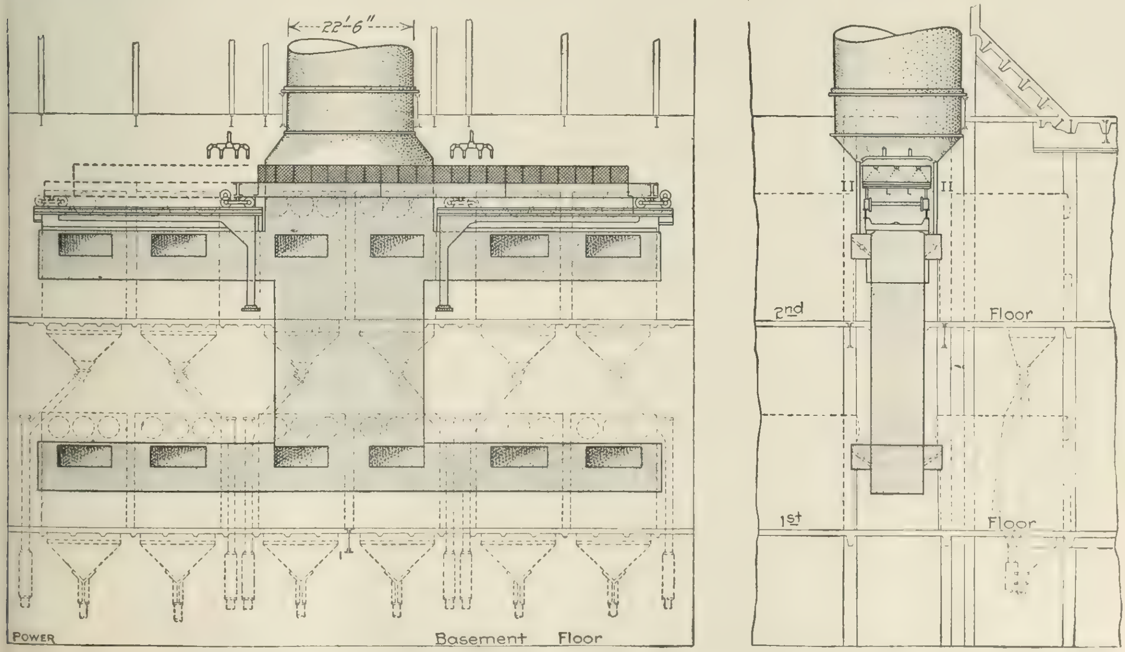

FIG. 6. RECIPROCATING SCREEN INTERCEPTING CINDER AT BASE OF STACK

cinder problem was a vital one to which ordinary methods and apparatus would not apply.

The original flues at Waterside No. 2 are shown in Fig. 5. The velocity of the gases through these flues was so high, that it could not precipitate the cinder, which was the original scheme planned.

Reciprocating Screen at Base of Stack

Before enlarging the flues, however, it was decided to try a large "sawtooth" screen of fine mesh, wider than the diameter of the base of the stack and over half as long as the flue. The reason for making it sawtooth fashion was to give it a much larger area than the base of the stack.

As shown in Fig. 6, this screen was mounted on wheels which ran on I-beams running parallel with the flue, the distance between the I-beams being slightly less than the width of the base of the stack. The stack was slotted so that this long screen could pass back and forth through it, thus intercepting the gases and catching the cinder before it reached the atmosphere. The general scheme is shown in the illustration.

At each side of the stack and above the screen was an air main containing air at 80 lb. pressure. The "drops" on this main were made to blow air into brushes which swept over the screen and removed the cinder from the mesh.

Beneath the I-beams over which the screen traveled was a concrete pit which received the cinder. As the cinder fell into this pit, water was run in, washing the cinder into pipes leading to the basement floor where the cinder was partly dried and disposed of.

This apparatus was discarded because when a screen of mesh fine enough to catch 50 per cent. of the cinder was used, the draft was seriously diminished and it was exceedingly difficult to clean the screen.

One would imagine that when nearly 50 per cent. of the cinder was trapped it would have stopped the complaints and convinced the company that it would not have to scrap apparatus costing thousands of dollars and experiment with other schemes. But there was further difficulty in this cinder problem, for as soon as a 25 or 50 per cent. gain was made in trapping the cinder, the new business (or load) so increased the coal consumption that the latter sometimes increased 25 per cent. while the cinder reduction also increased about 25 per cent. As the complainants got no relief, they kept up their protestations.

* * *

Softening Boiler Feed Water

By E. H. Robie

SYNOPSIS—A review of the principal systems, including boiler compounds, hot and cold processes, permutit and live steam purifiers; also the use of graphite and the luminator.

* * *

It is safe to say there are but few steam plants in this country using untreated water that are not troubled to some extent with scale or corrosion in the boilers. In this connection it might be noted that there is scale and scale. A New England engineer is apt to think that a deposit the thickness of a sheet of paper is bad indeed whereas the Middle Western engineer would be delighted if he could open his boilers and find only a quarter of an inch of scale on the tubes.

One is apt to get the impression that if only pure water were used, all troubles would vanish, but this does not necessarily follow as many people who have fed their boilers on water of condensation have found. Water that contains no mineral matter has been found to corrode iron in many cases. Just why it should do this is a disputed point, but the fact remains that it does, and as a result it is often an advantage to have a slight amount of mineral matter present.

Rain water as it leaves the clouds is pure. As it passes through the atmosphere it absorbs more or less carbonic-acid gas and air which it carries with it into the ground. As it seeps through the upper soil it will generally absorb still more carbonic-acid gas from the decaying animal and vegetable matter almost always present. Should the water fall on insoluble rocks, such as granite or marble, it will remain fairly pure. But if it passes through a layer of limestone, the carbonic-acid gas which it carries will cause it to dissolve away this rock, and as a result bicarbonate of lime will be present in the water. Should it pass through a layer of sulphate of lime or gypsum, the water will contain a large amount of this material.

It is generally known that the bicarbonates of lime and magnesia, when present in the water, form a comparatively soft scale; the sulphates of the same and also silica form a hard, flinty scale; the chlorides and nitrates are apt to cause corrosion; and the salts of soda and potash present, while not scale forming, are apt to cause foaming when sufficiently concentrated.

Boiler Compounds

The simplest, cheapest and most common method of softening boiler-feed water is by means of boiler compounds. Like other methods of softening, the boiler compound business has been largely put on a new basis in the last few years. Formerly, one compound was put on the market, which was supposed to be a cure for all ills. Nowadays the more progressive houses, first analyze the water and then prescribe. Often a stock of some three or four mixtures is kept on hand and that mixture used which is best fitted for the water. The basis of most of them is soda ash. Should the magnesium be high, caustic soda, lime or trisodium phosphate is often added. Sometimes paper pulp, waste from sugar houses and tanning factories or other organic matter is added

Boiler compounds are fed in several different ways The most rational is to have some arrangement whereby the feed is continuous and proportionate to the amount of water evaporated in the boiler. Often, however, a scoopful or a pailful is fed into the boiler all at once, a procedure certainly not to be recommended as it is liable to cause foaming, and besides an excess of medicine at one time will never make up for a lack of it during the rest of the day when raw scale-forming water is going to the boiler.

Even if the compound is what it should be and is properly fed, the boiler is no place for chemical reactions to occur. A water that contains much scale-forming matter will have the latter precipitated as sludge, and if the boiler is overloaded this is liable to bake on the tubes and become hard. Also, a large amount of suspended matter floating about in the boiler is particularly conducive to foaming.

In waters containing not more than four or five grains of scale-forming matter, it may be advisable to use some reagent directly in the boiler, rather than go to the expense of installing treating and filtering tanks. In such cases there will probably not be enough matter thrown down in the boiler to give any bad results provided proper care is taken to blow down the boiler frequently.

GRAPHITE

There is another class of substances closely allied to boiler compounds but whose action is mechanical rather than chemical. Perhaps the most important of these substances is graphite. When fed into the boiler this is supposed to adhere to the tubes, forming a smooth coating on which scale will not form. Advocates of this nonchemical process claim that anything strong enough to soften or remove scale will also attack the iron of the boiler.

Any chemist knows, however, that this is in error as reagents will attack sulphate or carbonate of lime which will not attack iron at all. For instance, a solution of soda ash, if fed into the boiler in proper amount and constantly, will in time soften the hardest scale, but the iron container in which the concentrated soda solution is kept will not be affected at all.

COLD PROCESS SYSTEM

The oldest commercial system of softening boiler feed water is known as the "cold process," in which the cold water is first treated with a solution of lime, either in the form of clear lime water or as milk of lime or cream of lime, which is much stronger. This is relied upon to precipitate the free carbonic-acid gas, the bicarbonate of lime and all of the magnesia present. The water is then treated with soda ash which precipitates all the remaining lime, which is in the form of sulphate, chloride or nitrate. The reason why these reactions take place may be simply stated as follows: If a chemical reaction takes place the general tendency is to form that product which is most insoluble. Take a water containing sulphate of lime, which is rather soluble, and add to it a solution of carbonate of soda—ordinary soda ash, and chloride of soda—ordinary salt. Now the lime could take three different forms. It could remain as the sulphate, or it could take the carbonate or chloride from the soda and become carbonate or chloride of lime. As has been already seen, sulphate of lime is readily soluble; chloride of lime is even more so, but carbonate of lime is almost insoluble, so this is what forms and it can be filtered out. All chemical methods of softening are based on this principle, of changing the lime and magnesia salts to an insoluble compound.

Sometimes the lime and soda are mixed together and added to the water all at once. What takes place is just the same, however, in the end. Also, for peculiar waters in which the impurities are proportioned in certain ways, caustic soda, barium hydrate and certain other chemicals are sometimes used. These are in general more expensive than the other chemicals.

It must be remembered that all substances are slightly soluble and the removal of every bit of the scale-forming matter cannot be obtained. It is almost impossible to get the carbonate of lime below two grains per gallon, and the hydrate of magnesia is also slightly soluble. Magnesia is a much more difficult substance to remove than lime and as a result there is usually a small amount of this substance remaining in the water above its solubility. It will in general do no harm. Complete removal of the scale-forming matter, although it can be done, is an expensive process and the more of it taken out, the higher the expense. The engineer should not, therefore, look for complete absence of sludge in his boilers unless he is willing to pay the price. A small amount of sludge will generally do no harm. He is entitled, however, to expect absence of hard scale or corrosion in the boilers, and if any is present, the makers of the softening system in use should be consulted.

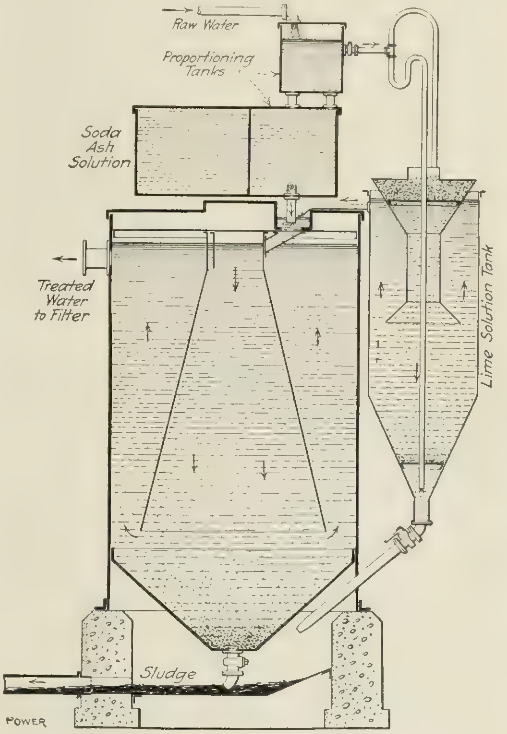

FIG. 1. ESSENTIALS OF COLD PROCESS SYSTEM

Cold-process systems possess certain disadvantages like most everything else. They are expensive in the first place, as large tanks must be erected for treating the water. A capacity of from one to three hours' supply should be provided, and more does no harm. The two chemicals used must be accurately proportioned, and with the somewhat complicated methods of testing often provided, a chemist is sometimes a necessity to tell just how much of the reagents to add. An excess of lime feed will form scale in the boiler just as if the lime was in the water originally. Then, too, power of some kind must generally be used to stir up the water and chemicals, and in most systems to raise the chemicals up to the top of the treating tank.

Nevertheless, the writer believes the cold process, as described, to be the most dependable and in many other ways the best method to soften water when it is wanted cold. The degree of softening is good provided the apparatus is properly operated, and a correctly made system will not cause much trouble from clogging or any other sources. The savings gained from the use of softened water will in general amply repay for the installation of a good system.

Hot Process System

Another system in common use is the hot process. This is based on the fact that the temporary hardness of water is removed simply by heating, without further chemical treatment. Dissolved gases are also removed by heating the water to the boiling point, as they are only soluble in cold water. Lime is, therefore, in most cases, dispensed with in the hot process system, and only one chemical is ordinarily used, generally soda ash.

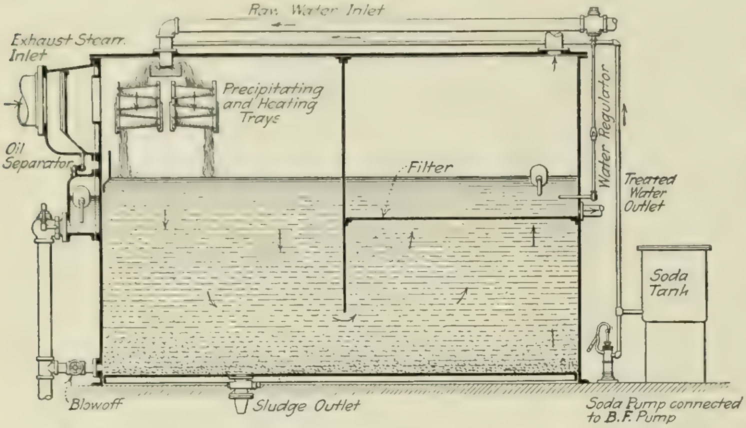

Fig. 2. Hot Process System Using Exhaust Steam

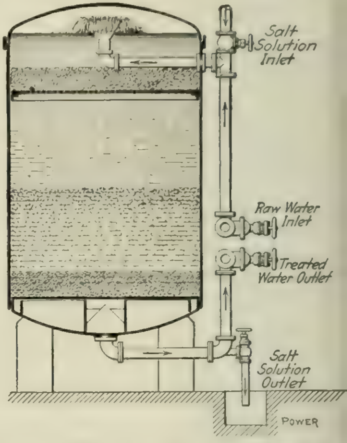

Fig. 3. The Permutit System, Closed Type

The water is first heated and this drives off the dissolved gases as already mentioned, which pass out of a vent at the top of the heater, or are carried off by the current of exhaust steam which is ordinarily the heating medium. Most of the carbonic-acid gas is driven off from the bicarbonates of lime and magnesia, and as the normal carbonate of lime is practically insoluble, most of it is precipitated here. Soda ash is then added to precipitate the balance of the lime and magnesia. With some waters of unusual character, another chemical is used in place of soda or in connection with it. Ordinarily this is not deemed necessary, however, as sufficient softening may be obtained with heat and soda alone.

Success of a softening system should never be based on the analysis of a treated water, but on the actual results in the boiler. It makes no difference to the practical engineer whether the treated water contains 100 grains of scale-forming matter per gallon, or 50 degrees of hardness, provided there is no hard scale in the boiler and there is no foaming or other trouble.

The chief disadvantage of the hot process is that when cold soft water is required, large cooling basins must be provided. For this reason when cold water is required it will in general be better to install a different process Also, care must be taken to keep the temperature up within a few degrees of the boiling point, the nearer the better. If this is not done an excess of soda ash must be used, which not only adds to the expense of operation but is liable to cause trouble in the boiler. Another disadvantage, paradoxical as it may seem, is that the hot process system is sometimes considered such a simple thing that it gets no attention. It might be a good idea for some of the manufacturers to have some wheels turning on the outside so that the engineer would be reminded that it was there and needed a certain amount of attention, such as filling up the soda tank and occasionally cleaning the filter.

The system affords a considerable saving in first cost since the tanks are not nearly so large. A capacity of about 20 min. supply is ordinarily allowed to give plenty of time for reaction and settling of the precipitated matter, and the tanks are usually incorporated with an open feed-water heater and are, therefore, made of cast iron instead of wood. Each 10 deg. rise in temperature is believed to about double the velocity of reaction, and, therefore, not nearly as large capacity for reaction has to be provided as in the cold process. The engineer can easily check this up by taking a sample of his feed water in a glass and adding a little pinch of compound or soda ash to it. If the water is cold, the precipitate will not form until after long standing, but if it is hot, the impurities will be thrown down almost instantly. This process also affords a saving in chemicals, inasmuch as lime is not required, its work being done by exhaust steam which would probably go to waste. Even if live steam is required, the water goes to the boiler hot instead of cold Even if a slight excess of soda is added no harm will be done, whereas an excess of lime will likely form scale

Live-Steam Purifiers

These are not used to any great extent and will only be taken up briefly. They rely on principles already stated for their operation. The purification tanks are under pressure, and the temperature of the water is considerably above the atmospheric boiling point, due to the injection of live steam. The high temperature breaks up the bicarbonates of lime and magnesia more completely han the heat in an ordinary hot process system. The sulphates, chlorides, etc., are not precipitated to any great extent, however, and this "permanent hardness" passes over into the boiler where it will form scale unless the water is further treated.

PERMUTIT PROCESS

The "Permutit" process of softening water is very little used in this country, although it has found considerable favor in Europe. Its discovery was comparatively recent. In this method the water is passed through a layer of an artificial zeolite—a complex silicate. The lime and magnesia in the water unite with the zeolite, the trade name of which is Permutit, and their place is taken by sodium salts. In this process, unlike the preceding ones, absolutely all of the scale-forming matter may be removed and the hardness can thus be reduced to zero. The working of the Permutit is absolutely automatic, but it must be regenerated at intervals of about 12 hr. by passing a concentrated solution of ordinary salt through the material. Double units must, therefore, be provided where the plant runs night and day. The filtering and treating apparatus varies in size from 1 ft. in diameter by 5 ft. high to 10 ft. in diameter by 12 ft. high.

A disadvantage of Permutit is that, although the hardness of the water may be reduced to zero, the total solids are not reduced at all as in other systems. The bicarbonates of lime and magnesia are transformed into bicarbonate of soda, and in water containing a large amount of temporary hardness the treated water is, therefore, very alkaline. The original cost of the Permutit is rather high, but there is little deterioration. The water flowing to the filter must be free from mechanical impurities and the temperature should not be over 100 deg. The field of Permutit would appear to be limited to cases where an alkaline water is desired or, at least, is not detrimental.

THE LUMINATOR

About the only other process used at all commercially is known as the "Luminator." In this process the cold raw water is allowed to run over aluminum plates before being fed into the boiler. Just what effect this aluminum treatment has on the water is unknown, but it is claimed to prevent the formation of scale. No scale-forming matter is removed before the water passes into the boilers and the Luminator should, therefore, be really classed in the boiler-compound group. It has been introduced only slightly in this country.

This completes the list of various methods of water softening. It is a subject on which much work has been done and there is really little excuse for hard scale formation in any steam boiler. Various tables have from time to time been published, showing the decrease in efficiency due to the presence of scale and the ordinary engineer can easily figure out just how much this troublesome stuff is costing in dollars and cents. Furthermore, there is also an added loss, due to the cost of cleaning, the decreased life of the boiler occasioned thereby, and the cost of repairs, such as tube and cap renewals. Almost any manufacturer of a softening system will be willing to guarantee a maximum cost of treatment, and by adding, say, 10 to 15 per cent. of the cost of the system to this to cover interest and depreciation, the saving due to the use of soft water may be easily reckoned.

Recent Court Decisions

Digested by A. L. H. STREET

Liability of City Operating Electric Plant—Although a city is not liable for negligence of its officers or employees while exercising strictly governmental functions, where it undertakes to furnish electric current to private consumers for profit, it becomes liable for injury to person or property resulting from negligence of its employees in stringing wires to be used for such commercial purposes. (New Jersey Court of Errors and Appeals, Karpinski vs. Borough of South River, 88 "Atlantic Reporter" 1073.)

Classification of Fuel Gas Rates—Under an ordinance prescribing different rates for fuel gas, according to whether it is used for "domestic consumption," "public institutions" or "manufacturers," a person who conducts an automobile garage, in which he uses a gas engine for the purpose of generating electricity to be used in his business, is entitled to the rate prescribed for manufacturers. (Louisiana Supreme Court, Henderson vs. Shreveport Gas, Electric Light & Power Co., 63 "Southern Reporter" 616.)

Effect of Contract to Supply Power—A mining company is bound by a contract, made by a person from whom property was taken over in exchange for one-third of the company's stock, to receive electric power for a period of three years, where the company continued to receive power in recognition of the contract for some time, although such person had not been elected a director and general manager of the company when he made the contract. (Kansas Supreme Court, Empire District Electric Co. vs. Eureka Mining Co., 136 "Pacific Reporter" 924.)

Assumption of Risk by Engineer—An experienced stationary engineer assumes the risk of being injured on account of the existence of such defective conditions surrounding the engine as narrowness of a space between the base on which the engine rests and the wheel pit, absence of adequate railing along the pit, and slipperiness of the floor caused by oil dropped by himself on the floor, especially where he has been in charge of the machinery for several days and, hence, is thoroughly acquainted with such conditions. (Texas Supreme Court, Snipes vs. Bomar Cotton Oil Co., 161 "Southwestern Reporter" 1.)

Rights of Way over Public Lands for Power Purposes—The act of Congress of July 26, 1866, confirming rights of way over public lands belonging to the United States, for the purpose of constructing ditches, etc., for the transportation of water for mining, agricultural, manufacturing or other purposes, granted rights of way for ditches and canals for the generation of electric power; generation of electricity being a beneficial use for which an appropriation of water might be had. (United States District Court, District of Utah; United States vs. Utah Power & Light Co.; 208 "Federal Reporter" 821.) The court further holds that defendant company, having obtained a right of way over public lands for a pipe line to conduct water for power purposes, the right was not affected by subsequent incorporation of the lands in a forest reserve. In his opinion in this case, Judge Marshall says: "I am satisfied that the defendant has title to a right of way for its pipe lines and reservoir under section 9 of the act of July 26, 1866, and was under no obligation to proceed under the subsequent legislation. But having elected to stand on the grant of section 9 and the amendment thereto including reservoirs, it cannot claim any additional right under this subsequent legislation."

Duty to Provide Safeguards in Engine Rooms—The owner of a power plant is liable for injury to a person directed to go into the engine room to "shut down the engine," if the accident is directly attributable to failure to provide a railing on a stairway leading to the room, or to failure to guard the machinery, although the person may not have been an employee at the plant, according to a recent decision of the Minnesota Supreme Court, in the case of Mitton vs. Cargill Elevator Co. (144 "Northwestern Reporter.") The court declined to determine whether the Minnesota statute which requires machinery, etc., in factories to be guarded was intended for the protection of persons other than employees; holding that liability for failure to discharge this duty exists in favor of any person who is requested to perform such service, whether he be an employee or not. In this case it appeared that the stairway consisted of eight steps, descending 6 ft. in a lateral distance of 3 ft. 9 in.; and that a flywheel and cog-wheels located near the foot of the stairway were not safeguarded. The man who went to the engine-room, having been fatally injured, it is not known whether the accident resulted from the lack of railing on the stairway, or want of guard on the machinery, but the court finds that the injury was caused by one of these elements.

Operating Characteristics of Centrifugal Pumps

By A. B. Morrison, Jr.

SYNOPSIS—From the operating standpoint rather than that of design. The effect of speed and head on the capacity and the influence of throttling the discharge vs. some form of speed control.

*

While centrifugal pumps are in general use in nearly all lines of work there is still, among many engineers, a lack of knowledge as to what their performance will be under anything but the conditions for which they happen to be installed. The man who has to operate the pump or is responsible for its operation is not particularly concerned with the reasons which prompted the designer to use an impeller with certain dimensions or with a certain blade angle, but he is interested in the effect which certain variables, such as speed and head against which the pump is to work, will have on the capacity if he wants to use the pump in some other location.

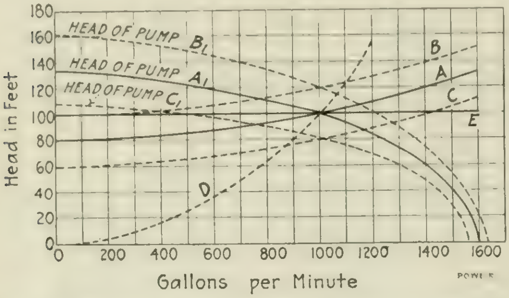

FIG. 1. QUANTITY-HEAD CURVES OF CENTRIFUGAL PUMP

He knows the centrifugal is not a positive pump but he is not able, usually, to forecast with any degree of accuracy how fast he ought to run the pump under new conditions to do certain work. It is generally stated that with a centrifugal pump the capacity varies as the speed, the head generated by the pump as the square of the speed, and the power required to drive the pump as the cube of the speed. While this is true theoretically of the pump and also under certain operating conditions, it does not mean, as is sometimes supposed, that to get an increase, for example, of 5 per cent. the pump should be speeded up 5 per cent, since the capacity discharged, as will be shown later, depends on certain characteristics of the system to which the pump is connected.

It is also desirable to know what effect throttling the discharge will have on the efficiency of the pump and whether it is better to use, where feasible, some form of speed control in preference to throttling. For these reasons, the writer believes that an article dealing with some of the more important characteristics of this type of pump, considered from the operating and not the design standpoint, will be of interest to many readers of POWER.

It is absolutely essential, in investigating the behavior of a centrifugal pump in operation, to know the head curve of the system to which the pump is to be connected and for that reason the head curve of the system will be considered before attempting to do anything with the centrifugal-pump curves proper. The head, which includes both suction and discharge, against which the pump works may be any one of three distinct classes: (1) Head entirely static; (2) head entirely friction; (3) head part static and part friction.

The first case seldom occurs in practice. If the pump were under a constant suction head, without any connecting piping, and the outlet of the pump were connected, without any piping, direct to a large standpipe of such size that practically no friction existed in it and in which the water, due to an overflow pipe, were at constant level, we would have the first case. In this instance, the head curve would be a straight horizontal line. Under similar conditions, no piping on suction or discharge, but with the standpipe gradually filling, the head curves would be represented by a series of horizontal lines taken at whatever distances apart were felt advisable to get the data required as to speed, capacity, etc., on the pump.

The second case mentioned is not common, either, but occurs more frequently than the first. It would be represented in practice by a level pipe with the suction and the discharge at the same level. The head curve under such conditions is shown in curve *E*, Fig. 1. In laying out such a curve the friction head at the rating of the pump, which we will call 100 per cent., is obtained from friction tables, showing the loss in head at the rated capacity of the pump through the size of pipe used. This gives one point on the curve, the capacity being represented always by abscissas (horizontal scale), and the head by ordinate (vertical scale). The friction head varies as the square of the velocity which, with a given pipe, is equivalent to the square of the quantity discharged. The following table shows the friction heads at less than rating, all quantitie being in percentage of those at rating:

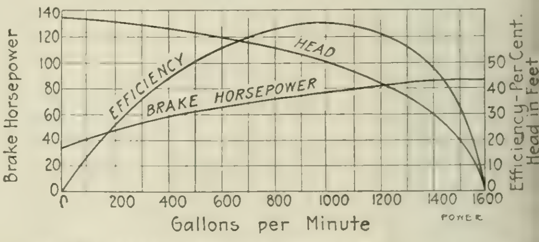

FIG. 2. CHARACTERISTIC CURVES OF A CENTRIFUGAL PUMP

Capacity in per cent....	90	80	70	60	50	40	30	20	10
Head in per cent......	81	64	49	36	25	16	9	4	1

The third case is the one which almost invariably occurs. In laying out this curve the ordinate at zero discharge is the actual elevation through which the liquid is to be raised. At any other rate of discharge the friction in the pipe, based on the quantity of water flowing is computed and the ordinate at this discharge is the static head plus the friction head. The general form of this curve is shown in curve *A*, Fig. 1, where it is assumed the head is based on 20 ft. of friction at the normal discharge (1000 gal.) of the pump. At any other point the friction head is computed from tables or can be readily ascertained in terms of the friction head at rating by using the table just given. At 125 per cent. of rating the friction head is 156¼ per cent. greater than at normal and at 150 per cent. of rating is 225 per cent. more than at normal, or based on 20 ft. of friction head at normal capacity these quantities are 31.25 ft. and 45 ft., respectively, to be added to the static head to secure the total head.

The characteristic curves of a centrifugal pump, as shown in Fig. 2, are more or less familiar to all engineers. While these curves differ for various makes and types, their general form is characteristic of all centrifugals. They are plotted for constant speed. One important fact to be noticed is that the head given by the pump depends entirely on the amount of liquid being pumped; or, to state it the other way around, the pump will discharge against a given head only a certain amount of water. The only way in which the head developed by the pump for a given discharge can be increased is by speeding it up. The discharge, as will be noticed, can be entirely closed without harming the pump.

In Fig. 1 the quantity-head curve of the given pump is shown together with the head curve of the system, both in heavy lines. For ease of computation the capacity at normal rating is taken as 1000 gal. per min. and the total head as 100 ft., composed of 80 ft. static and 20 ft. friction. Suppose, however, that it is desired to move the pump to a new location in which the static head is increased to 100 ft., the friction head at rating remaining unchanged, giving a total head of 120 ft., and it is desired to have the pump discharge the same amount as formerly, the new head curve *B* is obtained. Since the interception of the quantity-head curve of the pump with the head curve of the system gives the quantity of water which the pump will discharge it is evident that at the original pump speed only 76 per cent. of normal discharge will take place. To determine the new speed at which the pump must operate to give the head of 120 ft. necessary to discharge 1000 gal. per min., the pressure given by the pump is taken as proportional to the speed at which it operates. This is approximately true and close enough for all practical purposes. The relation then holds

100 (*head at normal speed*) : 120 (*head required*) : : *given revolutions squared* : *required revolutions squared*

Hence the required r.p.m. equals 109.5 per cent. of the original r.p.m., or the pump should be speeded up practically 10 per cent., to meet the new conditions and discharge practically the same amount of water as at first. The new quantity-head curve of the pump at approximately 10 per cent. increase in speed is shown by the dotted curve B_1 in Fig. 1. It has the same general form as the original.

If it is assumed that the static head on the pump is decreased to 60 ft., the friction head remaining the same, and the total head being 80 ft. in place of 100 ft., the new condition can be met in two ways. To meet the new head conditions by changing the speed of the pump, the former should be reduced in the proportion $\sqrt{100} : \sqrt{80}$, or to approximately 90 per cent. of normal at which the quantity-head curve at rating will exactly balance the computed head curve of the system and the pump will discharge its normal quantity of liquid. Curve *C*, Fig. 1, shows this curve of the pump at the reduced speed.

It is apparent, however, that this new condition can also be met by allowing the pump to operate at normal speed and by throttling the discharge so that only the head necessary to force 1000 gal. per min. through the system will be available, the rest being wasted in friction in the throttle valve. A comparison of these two methods will be taken up in detail later.

There is a further interesting fact brought out by these curves. It has been mentioned that the quantity discharged by a centrifugal pump is proportional to the speed, and that this is sometimes thought to mean that for a certain increase in speed the amount discharged is proportional to such increase. In Fig. 1, however, curve *E* is a head curve corresponding to the first case, viz., entirely static; curve *D* corresponds to the second case, entirely friction; and curve *A* is the third case. Taking curve *E* where the head is constant for all capacities, an increase in speed of approximately 10 per cent. produces an increase of 21 per cent. in the quantity discharged. For curve *D* the quantity discharged at 10 per cent. above normal speed is 10 per cent. more than normal or the increase is exactly proportional to the speed, and this is the only case where the relation holds.

In curve *A*, where the head is partly static and partly friction, an increase in speed of approximately 10 per cent. produces an increase in the volume discharged of 15 per cent. Furthermore, the only case where the head on a pump for a given discharge is exactly proportional to the square of the speed and the discharge is proportional to the speed is for the second case where the head is entirely friction. Hence, as stated earlier, the capacity discharged by the pump and consequently the head depend entirely on the head of the system against which the pump works.

So far, only the speed necessary to obtain a certain discharge under new conditions has been considered and no investigation made of the efficiency of the pump nor the power required to operate it. Unless this be known, there is the possibility of the motor or shafting being overloaded.

An approximate method for obtaining this horsepower, and one which is accurate enough for ordinary calculations, is as follows: The quantity in gallons per minute discharged at the new speed is divided by the new speed taken in percentage of normal. From the brake horsepower curve in Fig. 2 the horsepower corresponding to this quantity just obtained is found and this brake horsepower is multiplied by the cube of the new speed expressed in percentage of normal speed. The result is the brake horsepower required at the new speed. Applying this rule to the results shown by the curves in Fig. 1, the following results are obtained:

For curve *B*, 10 per cent. speed increase: Gallons discharged per minute, 1000; new speed in per cent. of normal, 110; $1000 \div 1.10 = 909$; b.hp. for 910 gal. per min. (Fig. 2), 37; $1.10^3 = 1.331$; $37 \times 1.331 = 49.25$ b.hp. required at 1000 gal. per min. and 120-ft. head.

B.hp. at 1000 gal. per min. and 100-ft. head (normal rating) = 38.5.

Increase 128 per cent., which is slightly less than the cube of the speed.

Applying the same methods to curve *C*, showing 10 per cent. decrease in speed, the b.hp. required is 29.2, or about 76 per cent of that required at normal, slightly more than if the power required were proportional to the cube of the reduced speed compared to the cube of the normal speed.

It has been seen that at the reduced head the pump can be run at normal speed by throttling the discharge until just the proper amount of water flows. In this case, though, the brake horsepower required is the same as when discharging the same quantity at the higher head, since the pump generates this higher head at the given speed and capacity. The net efficiency when throttled is the efficiency at the normal rating multiplied by the ratio between the head actually required and the normal pump head generated. Referring to Fig. 2, when pumping 1000 gal. per min. the pump generates a head of 100 ft. and the efficiency is 65 per cent. The head actually required by the system, as shown in curve C, Fig. 1, is 80 ft. Hence, the net efficiency of the pump at normal speed when throttled to 80-ft. head is

$$0.65 \times \frac{80}{100} = 52 \textit{ per cent.}$$

As a check on this result the brake horsepower required at normal speed pumping 1000 gal. per min., as given by Fig. 2, is 38.5. The water horsepower required at 1000 gal. per min. and 80-ft. head is

$$\frac{1000 \times 80 \times 8.33}{33,000} = 20.2$$

Hence the efficiency

$$\frac{\textit{water horsepower}}{\textit{brake horsepower}} = \frac{20.2}{38.5} = 52 \textit{ per cent.}$$

as just given.

With a variable-speed direct-current motor the proposition of securing the correct speed for any given set of conditions is easy and the motor efficiency and the overall efficiency of the equipment are unimpaired. Where it is necessary, however, in order to get any change in speed, to use resistance in series with the rotor, it is interesting to compare the combined efficiency of the pump and the motor obtained by this method with that obtained by throttling alone. Referring again to Fig. 1, the speed required at the reduced head, curve C, at 1000 gal. per min. is approximately 90 per cent. of normal. The horsepower calculated above for this discharge at 90 per cent. of normal revolutions is 29.2. In the case of a motor with resistance in series with the rotor, the efficiency at any reduced speed compared to that at normal speed with no resistance in the circuit is closely proportional to the revolutions at reduced speed compared with normal revolutions, so that reducing the speed to 90 per cent. of normal the efficiency is reduced correspondingly. In other words, at the reduced head

$$\frac{29.2}{0.90} = 32.4 \textit{ b.hp.}$$

is required when resistance in series with the rotor is used.

Tabulating the results, the following comparison based on reducing head to 80 ft., as shown by curve C in Fig. 1, is obtained. Each percentage gives the per cent. of brake horsepower required at rating:

B.hp. required by rotor control	32.4 = 84.4%
B.hp. required by field control on motor	29.2 = 75.8%
B.hp. required by throttling discharge	38.5 = 100 %

In other words, by using resistance in series with the rotor there is a saving of 6.1 b.hp., or 15.8 per cent., over throttling, and by using some form of variable-speed direct-current motor the saving is 9.3 b.hp., or 24.2 per cent. It is evident that where the head is likely to be less than normal for considerable periods and where the cost of power is important, some form of speed control is necessary. The variable-speed direct-current motor, as shown, is by far the best proposition. Armature control is sometimes used, but not often, as usually a variation of 10 per cent. or, at the most, 15, will take care of most installations and that can usually be obtained from any standard shunt-wound motor. With alternating-current motors, throttling is generally resorted to, owing to the special character of alternating-current variable-speed motors unless the installation is of fairly large size.

In working out curves for any given pump, the results obtained at various heads and rates of discharge will depend entirely on the characteristics of the particular pump and these may differ decidedly from the one used here as an illustration. If the pump has a steeper characteristic—i.e., if the head falls off more rapidly as the discharge increases—than the one shown, the difference in volume for any given change in speed will be less than for the curve given, whereas, with a flatter characteristic the change in volume for a given change in speed will be greater. With a flat characteristic, the head against which the pump works must be closely calculated in order to run the pump at the proper speed.

Wherever feasible, and especially if the pump is of large size, the writer wishes to emphasize the fact again, that some form of speed control should be used. It is almost impossible to determine accurately beforehand the head against which the pump will work, and with a fixed speed any change in piping or operating conditions may make a great difference in the amount discharged and in the power required.

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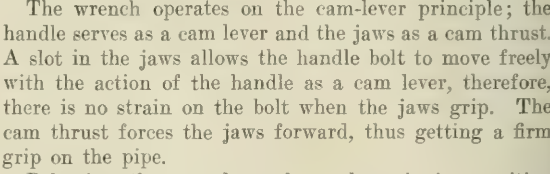
Gealy Chain Pipe Wrench

The principal points of construction of the Gealy wrench are found in the drop-forged steel handle and jaws, the teeth of which are tempered. The chain is of flat links, and can be had in special lengths if desired.



GEALY CHAIN PIPE WRENCH

The wrench operates on the cam-lever principle; the handle serves as a cam lever and the jaws as a cam thrust. A slot in the jaws allows the handle bolt to move freely with the action of the handle as a cam lever, therefore, there is no strain on the bolt when the jaws grip. The cam thrust forces the jaws forward, thus getting a firm grip on the pipe.

Releasing the cam lever from the gripping position loosens the grip of the chain and allows the wrench to be moved around on the pipe or removed from it.

The manufacturer, the Gealy Wrench & Manufacturing Co., Grove City, Penn., claims that this wrench has a positive grip and that it will not crush the pipe.

Editorials

Keeping Piping Costs

On account of the multiplicity of detail involved, accurate estimates of the cost of power-plant piping, at present are difficult to obtain in advance of construction. Here is where the engineer who is fond of compiling data can do a useful service tending to put this branch of power-plant work on a more scientific basis. Even though the total cost of piping, in most stations, is a small part of the whole installation expense, reliable figures on this subject are desirable, since every class of equipment which can be reduced to reasonably accurate estimates facilitates the larger mastery of the work by the station designer and by operating men required to figure the probable cost of new or remodeled equipment.

The important items in piping cost are obviously susceptible to labor and material classification. The kind of pipe employed for each class of service, its size and length, with the number of fittings involved; the material cost as delivered on the job, and the number, time and wages of fitters should not be unduly difficult to tabulate if the engineer can give a little attention to the task. Live steam, exhaust, feed-water and other piping systems are fortunately easily distinguished and are radically different in their bills of material. The chief difficulty comes in separating piping costs from installation expenses in connection with auxiliary apparatus which such piping serves in plants where the contractor puts in the entire equipment for which he is responsible with a force of erectors whose labor is not sufficiently separated by the timekeeper to permit the engineering classification desired.

The piping layouts in different plants must be compared in numerous ways in getting together material suitable for future estimates. Perhaps the most natural basis is the piping cost per kilowatt of plant capacity for each main and auxiliary system installed, including the labor and material classification, where this can be made, but, in any case, including the bill of material and, when possible, an estimate of the amount of time and its cost as required by the erecting force. This unit of comparison would apply to live-steam and exhaust piping, while an appropriate basis for feed-water piping might be the cost per boiler horsepower, for lubricating-system piping the cost per gallon of capacity, for air-compressor piping, the cost per foot of the dominating pipe size, for circulating-water piping the cost per foot per gallon per minute delivered, and so on. Sometimes an estimate of the total weight of piping and fittings involved may be desirable and the cost to a per-pound basis, including the expression of the weight of material required for plants of stated capacity.

In figuring new relatively simple work a bill of material should be prepared first, after which its approximate cost delivered can be determined by referring to similar material bills as classified by the engineer and checked, when possible, by quotations from piping-supply houses. If some effort has been made to tabulate the main items of cost, the engineer will find himself better able to judge bids and estimate forthcoming expenses. Where very many valves, tees, elbows and other fittings are needed, the total material cost per unit of capacity will doubtless be necessary, with a supplementary note as to the number of principal fittings required.

The space required to install the smaller sizes of pipe ordinarily does not complicate the question much from the point of view of installation labor. The larger piping space requirements depend considerably on the capacity of the generating units and auxiliary condensing apparatus; hence costs per kilowatt of capacity served are helpful.

Common sense should be applied when compiling and analyzing piping-cost data. Excessive subdivisions of such expense are of no advantage in dealing with very small installations, but the fact that piping estimates for the same job seldom vary 50 per cent., indicates that more attention to the subject is warranted than has been accorded it in the past.

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Concerning the Study Course

This week's installment of the Study Course concludes the lessons on trigonometry. These lessons have covered the fundamentals of the subject sufficiently to make possible the solution of any triangle, and the student should make himself thoroughly familiar with this much of the subject at least so that he may proceed intelligently with the course on mechanics to come later. Not that mechanics involves much trigonometry, but in the occasional problems where the latter is needed, it is indispensable.

For this reason it will be well for those following the course not to be content with solving only the five problems given with each lesson, but to make up for themselves others similar to those demonstrated, and more difficult ones, until they can do any problem involving the sides, angles and areas of either right or oblique triangles that is capable of solution. Preferably, examples should be made up and worked out that relate to the engineer's work in or about the plant. It will be surprising how many bits of useful information can be gained in this way concerning the plant or its apparatus that were otherwise unknown or at best learned less exactly by makeshift approximations. While the applications of trigonometry may seem few and of little importance at first, many will appear later when the study of mechanics is taken up.

It was the intention to follow the trigonometry section directly with the one on mechanics, but requests that two other matters be covered in the course, have led to the decision that they be introduced at this time. First will be given an explanation of the slide rule and its use, for it is a very handy tool to the engineer. Many are already using it and those that are not can hardly afford to remain in ignorance of its value. Especially is this true when the handling of it is so simple and proficiency so easily acquired. To see one used for the first time gives the impression that it is a mysterious instrument, but, once this false fear of it is overcome, with a little patience, all of its tricks can be learned. Then it is found to be surprisingly simple, and one wonders he has so long done without it. To use a common expression in advertising, "once used, always used," for probably no one who ever became acquainted with the slide rule was ever thereafter without one. Rules can be had now in such inexpensive forms that there really is no excuse for not owning one.

The other subject that has been called for is curve plotting. This, too, is extremely useful and likely also to be familiar to many who are following the course. It will do no harm, however, for them to have a little review of it and some who use it now to only a limited extent may get new ideas of its possibilities. No attempt will be made to exhaust this subject, nor to go into many of the more intricate forms, but only the simpler and most useful applications will be treated. As a check on mathematical calculations, curve plotting is of considerable service, but as a means of graphically presenting facts that may be clouded in a mass of figures, it is principally of value. In many of their forms, curves take the place of tables, giving quick means of obtaining values, and in other forms, as of plotted observations or other data, they show at a glance the law of variation and indicate what may be expected under other conditions in advance of their investigation.

Certainly the few lessons on the slide rule and curve plotting will be warranted for themselves alone and it is likely that they will be of no little advantage in connection with the mechanics course then to follow.

Conditions in the South

What is to become of the isolated power plants of the South? How soon will the hydro-electric central stations displace them with electrical energy developed from the many available water powers with which that section abounds?

Until recently, the power utilized in cotton mills and other factories was produced by comparatively small steam plants, except in the larger cities, where the steam central station had gained a permanent foothold. The small mill plant gave employment to firemen, oilers and engineers, and furnished a market for all kinds of power-plant apparatus. Now these men are being forced to look for other positions, because their steam plants are shutting down and hydro-electric power substituted. The market for small power-plant apparatus is becoming limited because comparatively few new steam plants are constructed.

It is predicted that within a few years in certain parts of the South the isolated plant will have been eliminated. The systems of electrical transmission which have been perfected make this prediction not only possible but probable. With the present facilities, electrical energy is being transmitted two hundred miles at high voltages, and then stepped down to voltages to suit the purchaser's requirements.

That there may be no interruption in service, most hydro-electric companies obtain control of steam central stations at various points on the transmission line and keep them for stand-by service, ready to be started if the water-power plants have trouble.

Arguments bringing out the reliability of hydro-electric service and the precautions taken against failure of electrical energy are attractive to the mill operator who has seen his production fall off, because of his own power-plant troubles. The promise of electrical energy at lower cost than when developed in the isolated plant is also an incentive to make a change.

Apparently, nearly all new cotton mills being built in the South will be operated by energy from hydro-electric stations. The chance of powering a new mill with an electrical steam plant is remote. The necessity of sustaining the initial cost of a power plant is eliminated and the absence of firemen, oilers and engineers on the payroll is attractive to the manufacturer.

Old established cotton mills will give a short respite to the power-plant operator. The hydro-electric plant has displaced but few of them, because it would mean discarding the steam apparatus and installing electric motors to drive the machinery. The cost would exceed what little, if any, saving was made by the change.

Power-plant owners do not seem to grasp their opportunities, nor do they learn by the experience and example of others regarding power-plant practice. After the engine is old and worn the steam consumption is excessive, requiring more boiler capacity and fuel. The power plants contain the ordinary equipment and no more and are practically left to take care of themselves.

The central-station manager aims to purchase fuel and supplies economically and provide instruments to ascertain if the best economy is being obtained; whereas the isolated-plant owner does neither, and then wonders why the power cost is excessive. The experiences of others who make a business of power for commercial use mean nothing to him.

Ignorance is the cause of most excessive power-plant costs. For instance, more power is needed to operate the machinery in the new part of the mill. Somebody decides the only thing is to install more boilers and a new engine, which usually requires an addition to the boiler and engine buildings and more help. This additional power becomes a burden from the beginning.

The man responsible for the new power-plant apparatus is not aware that, by adding a single generating unit and condenser outfit, the output of the old steam plant can be almost doubled without additional boilers or without additional boiler-room help.

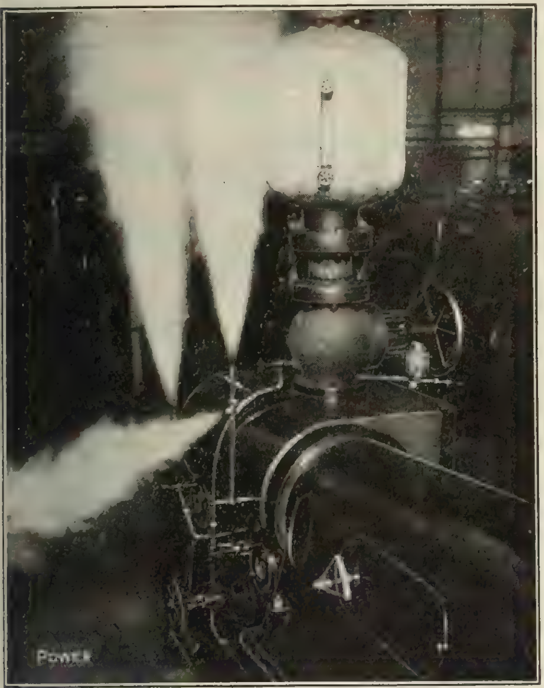
A mixed-pressure turbine to operate with the exhaust steam of the old reciprocating engine is not considered, probably because their economy in combination is not known, and yet, such a unit requires small floor space, does not draw an ounce of steam from the boilers, is operated by the engineer already in the plant and adds as high as ninety per cent. to the plant-load capacity, using the same amount of steam in the reciprocating engine as before.

Engineers should become familiar with the advantage of the mixed-pressure turbine and its value as a power producer in plants already established. There are instances where they would not be adaptable under some operating conditions, but in such plants the engineer must figure on other means for developing power cheaper than it can be purchased from the steam or hydro-electric central station. If they do not and cannot do this, there is every reason to believe that the operating days of their steam plants are numbered.

Correspondence

A "Tight" Engine That Leaked

We are sometimes mistaken about the condition of our engines. Recently I asked an engineer how the valve of his engine was holding—i.e., if it was steam-tight—and he replied that it was. The engine was running smoothly, as a badly leaking engine will at high speeds.



Evidence of Leaky Valve

I suggested that we test the valve for leakage. He placed the valve in its central position and opened the indicator-pipe connections and closed the valve in the exhaust line. On opening the throttle valve, the steam from the indicator-connection openings reached the ceiling as shown in the photograph.

He was a surprised engineer when the steam started to blow through the connections.

C. R. McGahey.

Baltimore, Md.

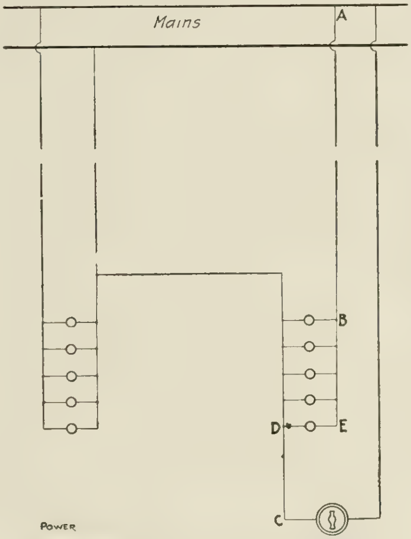
*

A Paradoxical Switch Connection

Calling on one of my engineer friends one day I found him in trouble. He had installed some new wiring that had to be in service that evening and it refused to work because the fuses would blow when he opened the switch. At first it appeared like a case of a short-circuit in the switch. Accordingly I disconnected and dissected the switch, but found nothing wrong, outside of the contacts being slightly burned. I then went to the fuse cabinet and, opening the main switch, replaced the blown fuses

There were two or three other circuits on this main switch besides the one having the paradoxical switch. This I had left disconnected, leaving the circuit open. Now, if my friend's theory were correct the fuses should blow as soon as the main switch had been closed, but this did not happen.

A new problem now arose: The lights on the open circuit which should have been out were burning. The trouble was evidently not in the switch, so I next gave my attention to the wiring, which was something of a Chinese puzzle, because in trying to economize on wire the engineer had made a number of combinations. The wires were run in molding; there were several branches and all on the main switch in the fuse cabinet with the exception of the one circuit, causing the trouble. This had a separate switch so that the lights in this circuit, which lighted a private office, could be cut out without interfering with the other circuits, which lighted the adjoining stock room. I finally made a sketch of the circuits and after eliminating the nonessentials found that they had been connected as shown in the diagram.



Original Switch Connections

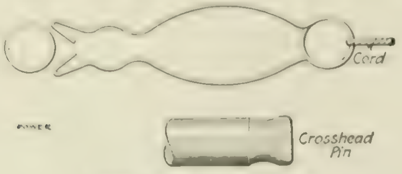
This, however, did not explain why the fuses blew when the switch was opened; obviously it should be just the reverse. A second examination proved this to be true and that what my friend had assumed to be the open position of the switch was really the closed position and when he closed the switch he had a dead short-circuit across the line and naturally the fuses blew. The mistake was rectified by cutting out the section *AB*, disconnecting the section *CD* at *D* and reconnecting it at *E*; also connecting the switch properly.

Chicago, Ill. Thomas G. Thurston.

Handy Hook for Indicator Cord

In the Nov. 1 issue, page 657, Mr. Baumeister describes an indicator cord hook for use with high-speed engines. If used on an inclosed type of engine, running between 275 and 300 r.p.m., I think the hook would give trouble in staying on the pin.

At one time I was going to indicate a 12x14-in. inclosed engine, running at 276 r.p.m., and encountered difficulties in getting the hook to stay on the pin. To overcome this trouble I made a hook, as shown by the accompanying sketch.



Indicator Cord Hook

It is used as follows: Hold the hook so that when the crosshead travels on its return stroke the pin will strike the points of the hook, opening them up, but as they close before the crosshead begins its opposite stroke, the hook and cord are carried with it. To unhook, run the hand down on the cord until it strikes the hook. The crosshead will then travel in the return direction until the pin comes to the enlarged part at the hook when, with a little sidewise pull, the hook is easily disengaged from the crosshead pin.

Fred W. Schneider.

Clay Center, Ohio.

⁂

Exhaust Muffler vs. Back Pressure

The sketch, Fig. 1, shows how the exhaust muffler was arranged on an oil engine and the manner in which changes were made in order to have the engine produce more power. The diagram, Fig. 2, was taken before the changes and shows the high back pressure at release. The engine had a 6-in. exhaust line leading from the engine to the flanged elbow, which had a 5-in. opening; the extension inside the muffler was 6 in. At the opposite end the muffler had a short section of 6-in. pipe and another 5-in. elbow with an upward extending exhaust pipe 6 in. in diameter.

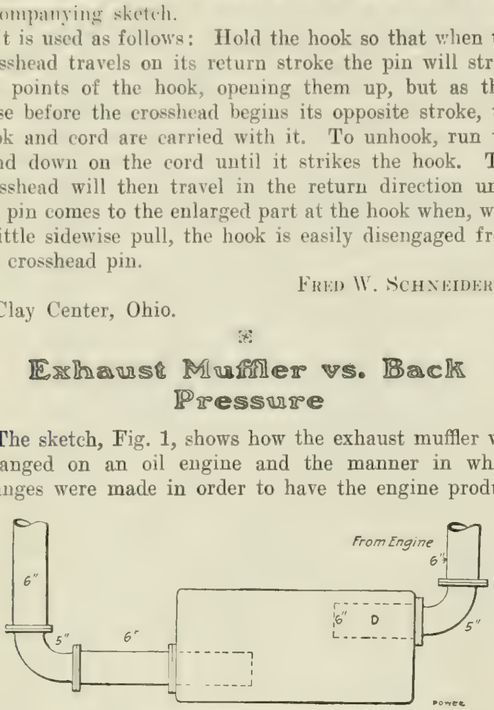


Fig. 1. Arrangement of Muffler

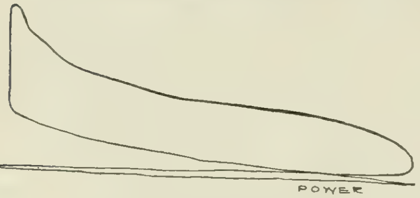


Fig. 2. Diagram Taken before Changing Elbow in Muffler

The 6-in. line and fittings had a cross-sectional area of 28.27 sq.in. and the 5-in. elbows an area of only 19.63, a difference of 8.64 in., the equivalent of a $3\frac{5}{16}$-in. circle. It is evident what a great difference this would have upon the working of the engine by causing excessive back pressure. The diagram, Fig. 3, was taken after two new 6-in. elbows had been substituted for the 5-in. elbows, and shows substantional reduction in back pressure. The diagrams were taken with a 100-lb. spring while the engine was running at 220 r.p.m.

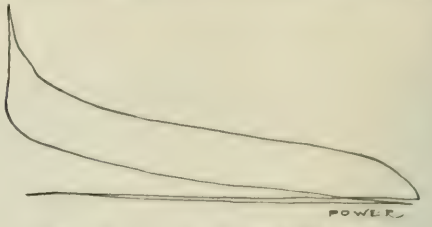


Fig. 3. Diagram after Making Change in Muffler

R. C. Hay.

Covington, Va.

⁂

Use of Tables

Engineers often fail to obtain benefit from valuable data because of the inconvenience of the arithmetical processes required for converting quantities into suitable units. For instance, water-meter readings are in cubic feet or gallons which have to be converted into pounds to determine the pounds of water evaporated per pound of coal, or gallons or cubic feet have to be converted into cubic inches as in determination of pump capacities.

When computations require the use of a constant multiplier, I have found this commonly used method convenient. Set out in tabular form for ready reference the products of the coefficient multiplied by the units from 1 to 10 and thus save intricate multiplications by dividing a multiplicand into tenths, hundredths, etc., and then take the sum of the products thus obtained with the proper number of zeros affixed to each term of the multiplicand. A simple example will suffice to show how meter readings in cubic feet may be converted into pounds of water at any average temperature, as 50 deg. F.

For this purpose set out a table for reference as follows:

1 cu.ft. of water weighs	62.41 lb.
2 cu.ft. of water weigh	124.82 lb.
3 cu.ft. of water weigh	187.23 lb.
4 cu.ft. of water weigh	249.64 lb.
5 cu.ft. of water weigh	312.05 lb.
6 cu.ft. of water weigh	374.46 lb.
7 cu.ft. of water weigh	436.87 lb.
8 cu.ft. of water weigh	499.28 lb.
9 cu.ft. of water weigh	561.69 lb.
10 cu.ft. of water weigh	624.10 lb.

A meter reading, such as 13,720 cu.ft., is then readily converted in pounds by affixing the appropriate number of zeros to the tabulated product for each figure and taking the sum as follows:

10,000 cu.ft. = 624,100 lb.
3,000 cu.ft. = 187,230 lb.
700 cu.ft. = 43,687 lb.
20 cu.ft. = 1,248.2 lb.

13,720 cu.ft. = 856,265.2 lb.

In the same manner, tables of the products 1 to 10 can be constructed with little trouble for ready reference for converting cubic feet to gallons, gallons to pounds, gallons to cubic inches, or for greater convenience in computing horsepower for different mean effective pressures using a given horsepower constant. With a few such tables adapted to his individual requirements, an engineer will find the task of making power-plant computations much less tax on his time and patience.

Medford, Mass. L. E. Thompson.

Running Cross-Compound Engine on Light Load

H. Rollins asks for discussion on this subject.

My method is to evenly distribute the load on the cylinders unless it is extremely light. On starting up, the best practice is to completely drain the main steam line, the cylinders and the receiver during the warming-up process. There is no occasion for apprehension on account of the high-pressure cylinder pulling water from the receiver as the pressure in the cylinder prevents the condensate from backing up.

A more imminent danger lies in the low-pressure cylinder expanding the steam to a lower vacuum than that maintained in the condenser. Such an occurrence might cause enough water to be drawn into the cylinder to wreck it. Therefore, I think it advisable to put most of the work on the low-pressure cylinder under extremely light load conditions to prevent the expansion of steam from lowering the pressure below that in the condenser.

Of course, similar conditions may arise in the receiver, due to the sudden diminishing of the load, when the receiver pressure may momentarily exceed the terminal pressure in the high-pressure cylinder. The remedy for this is a dependable steam trap.

It is impossible to lay down a rule for draining applicable to all engines or to estimate the possible results from water in the cylinder. I have seen an engine with the exhaust pipe rising above a 10-story building take over water and discharge it from the top of the pipe like a waterspout (for from 30 to 60 sec. at a time, notwithstanding the separator in the steam line), without the engine being damaged. On the other hand, engines have been wrecked by a single slug of water. There is little danger so long as the water does not exceed the capacity of the clearance space; in practice, however, much depends on the make of the engine, the lost motion in the journals, etc.

Mr. Rollins states: "I heartily agree that it (the receiver) should be well drained, but cannot see how an ordinary trap can drain a receiver when it has no pressure to make it work, or when the cutoff is so short that there is a vacuum in the receiver as the result."

I cannot conceive how such conditions are possible. Were the drain piped to the atmosphere, as Mr. Rollins assumes, the atmospheric pressure would not prevent the condensate from escaping, as it would enter the receiver, destroy the vacuum, and enable the trap to work by gravity. On the other hand, it would also raise the receiver pressure above the terminal pressure in the high-pressure cylinder, causing water to be drawn into it, possibly with disastrous results.

The best way of avoiding trouble from water is to connect the trap into the condenser. This would effect better operating conditions for the trap, and prevent the atmosphere from destroying the receiver vacuum.

As regards the reheating coil in the receiver, it is constructed for the purpose of circulating live steam at full boiler pressure, and I do not think that there is more danger to be expected from that source than from the bursting of the main steam or any other pipe carrying high-pressure steam.

Washington, D. C. Victor Bonn.

Pump with Cracked Spider

One morning while looking over the pumps in an ice plant I noticed that one of the duplex pumps was running in a most unusual way. It made three strokes all right, but the next one was slow and laboring. Steam could be heard going through the exhaust line just as if the steam and exhaust ports opened into each other. An examination showed the valve-gear to be in working order; the valves were properly set and no pieces had been broken from the valve or ribs; the piston rings were not loose enough to require a new set.

Finally the pump was taken apart and it was discovered that a steam-piston spider had close to the rod a small crack that ran into a sand hole, so that steam found its way through. When steam was admitted to the head end of the cylinder the rings held tight, but at the other end the steam went through the crack and sand hole, passing the follower plate and blowing directly into the exhaust. An $\frac{1}{8}$-in. boiler-plate patch stopped the trouble.

Chicago, Ill. A. G. Solomon.

The Slow-Speed Magneto

The desire for simplicity and reliability in gas-engine details has led to the adoption by many manufacturers of the slow-speed positive-driven magneto as the source of ignition current.

The one here described has been in use for three years at Oklahoma University and has proved eminently effective for make-and-break ignition. The magneto is a single-phase alternator, of the bobbin-wound type, as shown in Fig. 1. One end of the winding is grounded to the frame of the machine, and the other end is connected to the insulated end of the shaft against the center of which is the collector brush. One wire answers from the brush to the insulated igniter terminal.

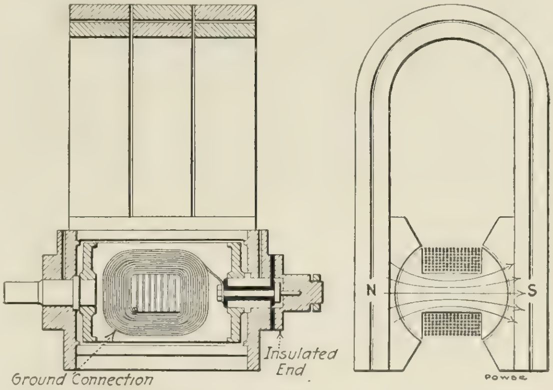


Fig. 1. Sectional Elevations of Magneto

Fig. 2 is from a photograph taken by the oscillograph in the electrical laboratory of the university, and shows

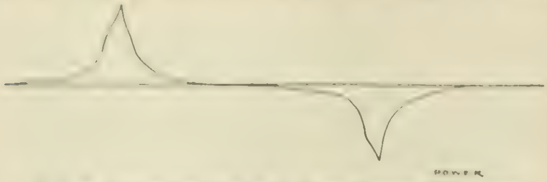


Fig. 2. Oscillograph for Slow-Speed Magneto

the current distribution for one revolution. The magneto is so timed that the igniter snaps at the peak of maximum current, and this is strong enough to start an engine at the ordinary hand-turning speed of about 50 r.p.m. The marks on the shaft collar and the frame of the machine indicate this maximum point.

Norman, Okla. William Aitkenhead.

*

Running Fans in Parallel

This is a usual occurrence in today's applications but the case L. B. Lent described in the Dec. 16 issue of Power is special. The most common arrangement of parallel application is with two separate fans on one shaft driven by a single motor. Such units as the turbine forced-draft sets installed in recent years by the New York Edison Co. are typical of this simple arrangement, and those installed on our modern torpedo-boat destroyers operate with two separate turbine-driven forced-draft fan units discharging into a closed fire room.

Both of these methods have proved successful. Experience teaches, however, that to prevent one fan from taking the load from the other, the two fans, not driven by one contiguous shaft, should have their speeds controlled by one regulating valve or throttle control. This control was symmetrically located with reference to the fan units and thus each of the turbines had steam delivered to their cases under identically the same conditions. The fan units were made from the same templates and dies so that they each carried an equal part of the load, due to their like characteristics. With electrically driven fan units in parallel the same care in selecting a single control for the motor units makes the problem simple and one need not feel the necessity of pitot-tube readings.

Personal experience on a recent test has shown that Mr. Lent's article should receive careful thought by those running more than one fan with common intake or discharge system. The owner was operating one fan at 315 r.p.m. by one throttle and the other at 356 r.p.m. by another throttle valve. The consequence was, that whereas either fan could have delivered 32,000 cu.ft. per min. against 2½ in. resistance at 356 r.p.m., air at 65 deg. F., both fans together gave but 41,000 cu.ft. per min. against 2½ in. One fan was stealing practically all the load from the other and the idle one consumed 10.5 b.hp. without doing much useful work.

I wish to supplement Mr. Lent's statement as to the pressure of a fan running blocked tight, the discharge pipe entirely closed, as being equal to that due to the lineal speed of the blades. This pressure is usually greater than that due to the lineal speed of the tip of the blades. I know of multivane fans that put up 2.6 times the pressure due to tip speed. This is true regardless of the double- or single-inlet, double- or single-width features in fans with one or more outlets. Even on fans with convex forward rotation of blades I have made tests where they would deliver their rated capacities against 33 per cent. greater pressure than tip-speed pressure and deliver the air at maximum efficiencies.

It would seem in Mr. Lent's case that instead of having to boost the speed of the fan running light above the speed (r.p.m.) of the fan running at higher speed in order to start a flow, the air flow should have started from the idle fan as soon as its tip-speed pressure equaled the static resistance maintained by the original fan.

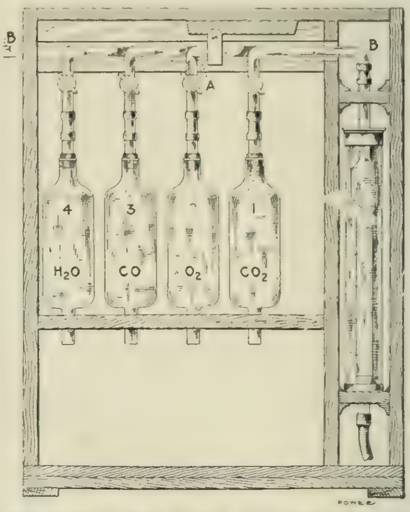
However, with a system already installed, it is readily seen that by throwing in the second fan one cannot expect to double the present delivery through the system except by increasing the r.p.m. of both fans. This produces the extra pressure necessary to overcome the added resistance caused by twice the volume flowing through the system. This pressure resistance would be four times the original static pressure resistance maintained at the entrance to the old system.

Boston, Mass. H. H. Valiquet.

*

Improvement for Orsat

I have made an improvement on the Orsat apparatus which does away with the gas bags attached to the absorption pipettes. This can be done by fitting a fourth pipette in the case. Practically all Orsat apparatus are built with sufficient room for this extra pipette. The rear legs of all four pipettes are then connected to a glass connecting tube or header *A*, as in the sketch, mounted in back of the main connecting tube *B*. The extra pipette is filled with water to the same level as the three containing the reagents and its front leg is left open to the atmosphere. Thus, a water seal is provided and the air in the back leg of any of the working pipettes is stored in the back leg of this end pipette when displaced by the manipulation of a gas sample.



View of Orsat from Rear, Showing Additional Pipette and Connections

The advantages of this arrangement are a neater looking equipment and the elimination of trouble due to the rubber gas bags developing leaks or becoming disconnected through any cause.

Bloomfield, N. J. G. A. deGraaf.

Engineers' Study Course

Trigonometry--XI

LAST LESSON'S ANSWERS

46. Given $a = 9$, $b = 12$ and $c = 15$.

This is a Case IV problem and the three angles are found by the three forms of equation 31 (last lesson).

$$\cos A = \frac{12^2 + 15^2 - 9^2}{2 \times 12 \times 15} = \frac{288}{360} = 0.8$$

Therefore, angle A = 37 deg., closely.

$$\cos B = \frac{9^2 + 15^2 - 12^2}{2 \times 9 \times 15} = \frac{162}{270} = 0.6$$

Therefore, angle B = 53 deg., closely.

$$\cos C = \frac{9^2 + 12^2 - 15^2}{2 \times 9 \times 12} = \frac{0}{216} = 0$$

Therefore, angle C = 90 deg.

Check:

$$37 + 53 + 90 = 180$$

This proved to be a right triangle and it could have been predicted at the outset, as the sides are respectively proportional to 3, 4 and 5.

47. Given $a = 94.596$, $b = 104.653$ and $c = 100$.

This also is a Case IV problem and is solved in the same way as the last.

$$\cos A = \frac{104.653^2 + 100^2 - 94.596^2}{2 \times 104.653 \times 100} = 0.5736$$

Therefore, angle A = 55 deg.

$$\cos B = \frac{94.596^2 + 100^2 - 104.653^2}{2 \times 94.596 \times 100} = 0.4226$$

Therefore, angle B = 65 deg.

$$\cos C = \frac{94.596^2 + 104.653^2 - 100^2}{2 \times 94.596 \times 104.653} = 0.5$$

Therefore, angle C = 60 deg.

48. Calling the three sides of the pond a (100 ft.), b (150 ft.) and c (75 ft.), the solution will be as in the two previous problems

$$\cos A = \frac{150^2 + 75^2 - 100^2}{2 \times 150 \times 75} = \frac{18{,}125}{22{,}500} = 0.8055$$

Therefore, the angle A = 36⅓ deg., about.

$$\cos B = \frac{100^2 + 75^2 - 150^2}{2 \times 100 \times 75} = \frac{-6875}{15{,}000} = -0.4583$$

The sign being negative, the angle B is of the second quadrant or greater than 90 deg.; therefore it will be the supplement of the angle found from the table, or

$$180 - 62.7 = 117.3 \textit{ or about } 117\tfrac{1}{3} \textit{ deg.}$$

$$\cos C = \frac{100^2 + 150^2 - 75^2}{2 \times 100 \times 150} = \frac{26{,}875}{30{,}000} = 0.8958$$

Therefore, the angle C = 26⅓ deg., about.

Check:

$$36\tfrac{1}{3} + 117\tfrac{1}{3} + 26\tfrac{1}{3} = 180 \textit{ deg.}$$

49. First find the area of the surface of the pond by equation 32 (last lesson).

$$area = \tfrac{1}{2} \times 100 \times 75 \times 0.8886 = 3332.25 \textit{ sq.ft.}$$

The depth being 5 ft., the volume will be

$$3332.25 \times 5 = 16{,}661.25 \textit{ cu.ft.}$$

or, there being 7.48 gal. to 1 cu.ft.,

$$16{,}661.25 \times 7.48 = 124{,}626.15 \textit{ gal.}$$

50. The base of the triangular guard being 6 ft. and its altitude 8 ft., its area is

$$area = \tfrac{1}{2} \times 6 \times 8 = 24 \textit{ ft.}$$

Then from equation 32 the sine of the angle between the two known sides may be found

$$24 = \tfrac{1}{2} \times 8\tfrac{1}{2} \times 6 \times \sin B$$

$$\sin B = \frac{24}{\frac{1}{2} \times 8\frac{1}{2} \times 6} = \frac{24}{25.5} = 0.9412$$

Therefore, angle B = 70¼ deg., closely.

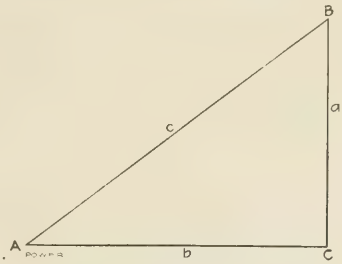


FIG. 13

The angle required, however, is the one opposite the base, or C, making this part a Case III problem. Using the first method for that case:

$$\tan \tfrac{1}{2} (A - C) = \frac{8\frac{1}{2} - 6}{8\frac{1}{2} + 6} \times \tan \tfrac{1}{2} (180 - 70\tfrac{1}{4})$$

$$= \frac{2.5}{14.5} \times 1.4216 = 0.2451$$

Therefore ½ $(A - C)$ = 13.77 deg., about, and

$$C = \tfrac{1}{2} (A + C) - \tfrac{1}{2} (A - C) = 54.88 - 13.77 = 41.11$$

or practically 41 deg.

REVIEW

Trigonometry is a branch of mathematics mainly concerned with the solution of triangles and involving certain ratios of angles and sides, known as functions of angles.

Given a side and any other two of the six parts of a triangle—the three sides and the three angles—and the unknown parts may be determined.

The ratios known as trigonometrical functions of an angle are

$$\textit{sine} = \frac{\textit{opposite side}}{\textit{hypotenuse}} \qquad \sin A = \frac{a}{c} \text{ (Fig. 13)}$$

$$\textit{cosine} = \frac{\textit{adjacent side}}{\textit{hypotenuse}} \qquad \cos A = \frac{b}{c}$$

$$\text{tangent} = \frac{\text{opposite side}}{\text{adjacent side}} \qquad \tan A = \frac{a}{b}$$

$$\text{cotangent} = \frac{\text{adjacent side}}{\text{opposite side}} \qquad \cot A = \frac{b}{a}$$

$$\text{secant} = \frac{\text{hypotenuse}}{\text{adjacent side}} \qquad \sec A = \frac{c}{b}$$

$$\text{cosecant} = \frac{\text{hypotenuse}}{\text{opposite side}} \qquad \csc A = \frac{c}{a}$$

$$\text{versed sine} = 1 - \text{cosine} \qquad \text{vers } A = \frac{c - b}{c}$$

$$\text{versed cosine} = 1 - \text{sine} \qquad \text{covers } A = \frac{c - a}{c}$$

The complement of an angle is the difference between 90 deg. and the angle. Any function is equal to the co-named function of the complementary angle.

The supplement of an angle is the difference between 180 deg. and the angle.

The sum of the three angles of a triangle is 180 deg. Therefore, any one of the angles is the supplement of the sum of the other two, and in a right triangle the acute angles are complements of one another

Angles from 0 to 90 deg. are of the first quadrant, 90 to 180 deg. of the second, 180 to 270 deg. of the third and 270 to 360 deg. of the fourth quadrant.

For angles of the various quadrants the signs of the functions are

	sin	cos	tan	cot	sec	csc
1st quadrant	+	+	+	+	+	+
2nd quadrant	+	—	—	—	—	+
3rd quadrant	—	—	+	+	—	—
4th quadrant	—	+	—	—	+	—

Following is a short table of the values of the functions for the more common angles:

Angle	sin	cos	tan	cot	sec	csc
0°	0	1	0	∞	1	∞
30°	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{3}}$	$\sqrt{3}$	$\frac{2}{\sqrt{3}}$	2
45°	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	1	1	$\sqrt{2}$	$\sqrt{2}$
60°	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$\sqrt{3}$	$\frac{1}{\sqrt{3}}$	2	$\frac{2}{\sqrt{3}}$
90°	1	0	∞	0	∞	1
120°	$\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$-\sqrt{3}$	$-\frac{1}{\sqrt{3}}$	—2	$\frac{2}{\sqrt{3}}$
135°	$\frac{1}{\sqrt{2}}$	$-\frac{1}{\sqrt{2}}$	—1	—1	$-\sqrt{2}$	$\sqrt{2}$
150°	$\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	$-\frac{1}{\sqrt{3}}$	$-\sqrt{3}$	$-\frac{2}{\sqrt{3}}$	2
180°	0	—1	0	∞	—1	∞
270°	1	0	∞	0	∞	—1
360°	0	1	0	∞	1	∞

(∞ is the sign for infinity and means the increasing of a number beyond all limits. As applied to a line representing a function it is an imaginary one continuing throughout space without an end.)

The ten fundamental relations which the trigonometrical functions of any angle bear to one another are:

$$\sin^2 A + \cos^2 A = 1$$

$$\tan A = \frac{\sin A}{\cos A}$$

$$\cot A = \frac{\cos A}{\sin A}$$

$$\cot A = \frac{1}{\tan A}$$

$$\sec A = \frac{1}{\cos A}$$

$$\csc A = \frac{1}{\sin A}$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\csc^2 A = 1 + \cot^2 A$$

$$\text{vers } A = 1 - \cos A$$

$$\text{covers } A = 1 - \sin A$$

For the functions of the sum and difference of tw angles there are eight principal formulas, as follows:

$$\sin (A + B) = \sin A \cos B + \cos A \sin B$$

$$\sin (A - B) = \sin A \cos B - \cos A \sin B$$

$$\cos (A + B) = \cos A \cos B - \sin A \sin B$$

$$\cos (A - B) = \cos A \cos B + \sin A \sin B$$

$$\tan (A + B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$$

$$\tan (A - B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}$$

$$\cot (A + B) = \frac{\cot A \cot B - 1}{\cot B + \cot A}$$

$$\cot (A - B) = \frac{\cot A \cot B + 1}{\cot B - \cot A}$$

For the functions of twice an angle there are fou principal formulas, which are

$$\sin 2 A = 2 \sin A \cos A$$

$$\cos 2 A = \cos^2 A - \sin^2 A$$

$$\tan 2 A = \frac{2 \tan A}{1 - \tan^2 A}$$

$$\cot 2 A = \frac{\cot^2 A - 1}{2 \cot A}$$

For the functions of half an angle, also, there are fou principal formulas:

$$\sin \tfrac{1}{2} A = \pm \sqrt{\tfrac{1}{2} (1 - \cos A)}$$

$$\cos \tfrac{1}{2} A = \pm \sqrt{\tfrac{1}{2} (1 + \cos A)}$$

$$\tan \tfrac{1}{2} A = \pm \sqrt{\frac{1 - \cos A}{1 + \cos A}}$$

$$\cot \tfrac{1}{2} A = \pm \sqrt{\frac{1 + \cos A}{1 - \cos A}}$$

Any right triangle can be solved if one side and a acute angle or two sides are given. When two sides ar known the third can be found by the relation that th square of the hypotenuse is equal to the sum of th squares of the other two sides. The angles are found b applying the formulas for the functional relations give above, as

$$\text{sine} = \frac{\text{opposite side}}{\text{hypotenuse}}, \text{ etc.}$$

All oblique triangle problems come under four cases:

Case 1. Given one side and two angles. The third angle is found by subtracting the sum of the two know angles from 180 deg. and the sides by the application o the Law of Sines: The sides of a triangle are proportional to the sines of the opposite angles; or, expressed,

$$\frac{a}{b} = \frac{\sin A}{\sin B}, \text{ (Figs. 14 or 15)}$$

Case II. Given two sides and an angle opposite one of hem. By the Law of Sines first the angle opposite the other known side, then the third angle and finally the third side are found.

Case III. Given two sides and the included angle.

First Method. The sum of the other two angles will equal 180 deg. minus the given angle and the difference between the other two angles may be found by the Law of Tangents: The sum of the two sides of a triangle is to their difference as the tangent of half the sum of the opposite angles is to the tangent of half their difference; expressed

$$\frac{a+b}{a-b} = \frac{tan\ \frac{1}{2}\ (A+B)}{tan\ \frac{1}{2}\ (A-B)}$$

or

$$tan\ \tfrac{1}{2}\ (A-B) = \frac{a-b}{a+b} \times tan\ \tfrac{1}{2}\ (A+B)$$

Then each of the two unknown angles can be found, for the larger will be equal to half their sum plus half their difference; expressed

$$A = \tfrac{1}{2}\ (A+B) + \tfrac{1}{2}\ (A-B)$$

and the smaller will be equal to half their sum minus half their difference; expressed

$$B = \tfrac{1}{2}\ (A+B) - \tfrac{1}{2}\ (A-B)$$

The third side can then be found by the Law of Sines.

Second Method. The third side may be found directly by the Law of Cosines: The square of any side of a triangle is equal to the sum of the squares of the other two sides, less twice the product of the sides and the cosine of the included angle; expressed

$$a^2 = b^2 + c^2 - 2\ bc\ cos\ A$$

and the two unknown angles found by the Law of Sines.

Case IV. Given the three sides. The angles may be found directly by the Law of Cosines.

The area of any triangle is equal to one-half the product of its base by its altitude; expressed

$$area = \tfrac{1}{2}\ ch\ \text{(Figs. 14 or 15)}$$

or, one-half the product of two sides and the sine of the included angle; expressed

$$area = \tfrac{1}{2}\ ac\ sin\ B$$

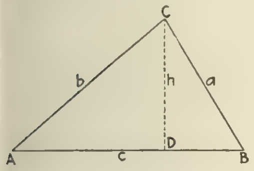


FIG. 14

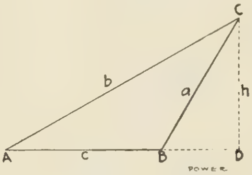


FIG. 15

⁂

Resistance of Tungsten at High Temperatures—Accurate measurements on the electric resistance of tungsten at high temperatures have been made by Pirali. He uses a strip of this material 2.4 in. long, 0.05 in. wide, and 0.002 in. thick, mounted in an exhausted bulb. The strip is soldered to a pair of very fine wires as a support, so as to have the heat radiation uniform; which is not the case where the filament is attached to the support of an ordinary lamp, for the support carries away the heat from the ends of the filament and makes these cooler than the remainder. He takes the temperature of the tungsten strip by using a Holborn pyrometer, and finds that the ratio of the resistance at high heats to the resistance in the cold at 20 deg. C. (taken as unity) is 7 for 1200 deg. C., 10 for 1600, and 12 for 1900 C.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Would you live in a vacuum?" asks George Fitch in "Collier's." Not on our suburban home we wouldn't. There's nothing in it!

⁂

The hydro-electric plant is much more than a generator of juice, if we accept this piece of pretty sentiment from "Compressed Air":

"Our desert spots are made to blossom like the rose, transfigured from barren arid wastes into gardens of flowers and fields of grain, by the use of hydro-electric power."

⁂

If you wish to live to good old age, take a spoonful of lubricating oil every day, says Doctor Lane, a famous English surgeon. That's all right for the Eskimos, but who wants to be an Eskimo?

⁂

Up to May 30, 1913, the Panama Canal cost $295,587,148.41, and to keep the Canal Zone healthy over $16,000,000 was expended. These total to a comfortable little bunch of money, but if it all had to be done over again, 'twould be worth it.

⁂

Vice-President Marshall has said that "500,000 young people annually come from our schools to achieve success in life, and 400,000 are failures." This is hard to believe. While we cannot all hope to be Vice-Presidents, most of us are earning a decent living, educating our children and putting by a dollar against the rainy day. Aren't we a success in a small way, and hasn't Success left her mark among the humble as well as the great? Sometimes T. Riley Marshall's utterances evince a need for pepsin right after his meals.

⁂

Happen to know Billy Dugan, over to Butler, N. J.? Well, anyhow, Billy thinks we fell over the spillway on Jan. 1, for his Jan. 6 "Power" had several blank pages. Once in a short lifetime a sheet will creep into the paper printed on one side only. Our mechanical department is only human—and so is Billy, for he forgives us.

⁂

"It would be obvious to any mechanic that a right-handed drill would be used to extract a left-handed screw, and a left-handed drill to extract a right-handed screw," says a patent examiner. The "Valve World" remarks that "C. L. Redfield, M. E., a Chicago patent solicitor, evidently with a memory of his own apprentice days, observes that now, in addition to hunting for a left-hand monkey wrench or a half-round square, the poor apprentice will be required to drill left-handed holes."

⁂

When Doctor Humphreys urged the choosing of engineers for public-service commissioners, did he have in mind the Massachusetts Board's ready consent for the New Haven's latest scheme to exploit its property for the bankers' benefit? Bleeding stockholders of $68,000,000 is scattering the gore rather too promiscus. Don't believe this proceeding would have been permitted if this board had been composed of engineers who have ethics on tap.

⁂

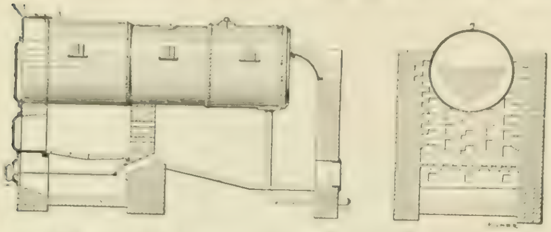
"One day on approaching our factory," writes an American engineer in Cuba, "I noticed a great cloud of smoke, oily and black, rolling out of the chimneys and blotting out the surrounding landscape. I went to the boiler room and gave the firemen a good dressing-down for allowing so much smoke to escape, telling them that it was throwing money away, and that if they could not fire better I would have to discharge them. I thought no more of it till the next morning when on entering the engine room I found the chief mechanic jubilant over some joke. He told me that the chief fireman, a negro, had come to him with tears in his eyes and had said: 'Mr. U says that we must not let the smoke go out of the chimney; if we do he will discharge us. Now, if the smoke cannot go out of the chimney, where can we put it?'"

Building a Smokeless Furnace

By E. E. Clock

All smoky furnaces need an increased bulk of firebrick to absorb heat at the time of greatest production in order to give it off at times of least heat production. A furnace must be reverberating to successfully prevent smoke, and with a properly designed furnace of heavy arches and reverberatory weight of firebrick there is no need of smoke. Smoke from such a furnace is the result of carelessness.

It is with the common type of furnace usually associated with a horizontal, return-tubular boiler that I wish to deal. Such a furnace can be constructed with sufficient reverberatory weight and surface of firebrick to successfully burn any grade of hard or soft coal without smoke, providing one boiler is not compelled to do the work of two.



Design for a Smokeless Boiler Furnace

The standard plans for setting return-tubular boilers, it is said, originated in Pittsburgh. These plans have been handed along until it is time the authorities took cognizance and provided a fine and imprisonment for anyone found guilty of constructing such a boiler furnace within the city limits.

Municipal control of the construction of all coal-burning furnaces should be had and free plans furnished by the municipality; if smoke-making boiler plants were prohibited atmospheric purity would be greatly improved.

The side walls of a reverberatory furnace should be ribbed or corrugated. Set one row of bricks end to end, with the side exposed in the usual way; set the next row side by side, the end of each brick protruding half its length, alternating the courses so that one course is in half a brick, the next one out half a brick to the top of the setting, as shown in the illustration. This setting should not begin until above the fire line at the grates, and above the ash line at the combustion chamber. The bridgewall should be built 18 in. thick and right up to the boiler, making a complete cross wall from side to side. This wall above the fire line is to be perforated with holes or slots of sufficient area to equal the area of the air space of the grate.

In laying the foundation for such a bridgewall, four hollow wooden forms, about 3x4 in., should be placed so that one end will protrude through the front, below the grate, and the other end through the back of the wall just below the lowest line of holes or slots, arranging stoppers on long rods to come through the front of the furnace below the grates for controlling the draft through these flues.

The grates will then send to the combustion chamber gases that are properly heated and mixed. Thus by regulating the admission of air through the ducts below the grates, according to the weight and imperviousness the contents of the grates, one will be able to control t action of the furnace to the desired combustion of combustible; the most important action will be in fir only one side at a time. Such a furnace should be pr vided with peep holes to the combustion chamber. Th furnace will burn soft coal with no signs of smoke at t chimney.

It should be remembered that the boiler itself is condenser or arrester of combustion, therefore the pro ucts of combustion should be kept away from the co surfaces of the boiler as far as possible until they a thoroughly mixed with air and heated. Fire one side the furnace at a time, and when the furnace door is op the damper in the uptake of that boiler should be close automatically if possible.

It is not absolutely necessary that the perforated wa be built on top of the bridgewall; it can go back a foo or so. Many furnaces can be helped by placing a perforate mass of firebrick in the combustion chamber and intro ducing proper firing methods.

*

Graphical Determination of Trigonometric Functions

The Trigograph, a small reproduction of which i shown in Fig. 1, is a chart with which it is possible t obtain the natural functions of angles graphically to slide rule accuracy.

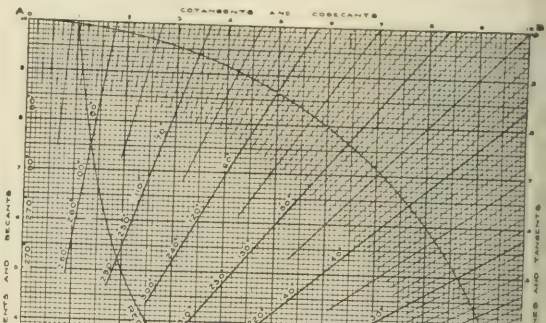


Fig. 1. The Triograph. Reproduction about Half Size

The quadrant shown is one of unit radius and is divided into 90 deg. Angles having the same numerical values (but not necessarily of the same sign) are marked in their corresponding positions. This enables one to read the natural functions for any angle from 0 to 360 deg.

The method of reading will be understood by referring to Fig. 2. The square *ABCD* is divided into equal spaces.

The divisions on *AB* represent numbers from 0 to 10, on *CB* from 0 to 1, on *DC* from 0 to 1 and on *DA* from 0 to 10. *AKC* is a circle described about *D* as a center and has a radius equal to unity. *LMN* is a hyperbolic curve and has for its equation $Y = 1/X$. It is plotted using values on *DC* as abscissas and values on *DA* as ordinates. Thus, 0.2 on *DC* corresponds to 5, or the reciprocal of 0.2, on *DA*. It will be noticed that if this same curve be plotted, using the values on *CB* as abscissas and the values on *AB* as ordinates the curve will fall along the same points. Therefore, with this curve one may find the reciprocal of any value on *DC*, or the reciprocal of any value on *CB*, by locating the corresponding values on *DA* or on *AB*.

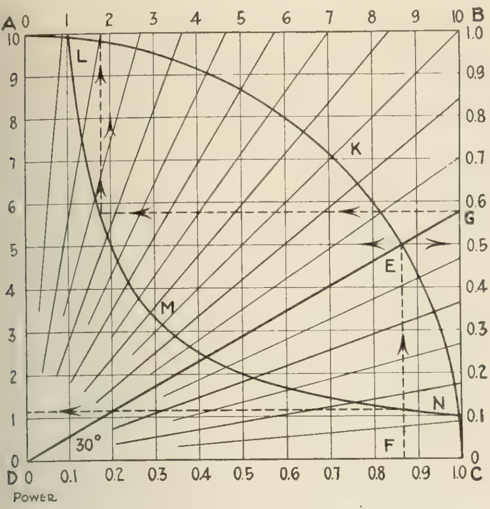


Fig. 2. Diagram Illustrating the Use of the Trigograph

The functions of any angle, for example, 30 deg., which on the diagram is the angle *GDC*, are found as follows:

Sine—Drop a line as *EF* from the point where *DG* intersects the circumference of the unit circle. Here is a right triangle, *DFED*, the angle at the vertex *D* being 30 deg. Then *FE*/*DE* equals *sin* 30°. *DE* equals 1, being equal to the unit radius. Therefore, *FE* equals *sin* 30°, and its value is 0.5, as indicated by arrows on *CB* to the right.

Cosine—Considering the same triangle, *DF* /*DE* equals *cos* 30°. Therefore, *DF* equals *cos* 30° and its value is 0.866 as read directly on *DC*.

Tangent—Now, refer to the triangle *DCGD*, which is similar to the triangle *DFED*, the angle at the vertex *F* being 30 deg. Then, *CG*/*DC* equals *tan* 30°. *DC* equals 1 (by construction). Therefore, *CG* equals *tan* 30° and its value is 0.577 as read directly on *CB*.

Cotangent—Since *cot* 30° equals 1/ *tan* 30°, read the reciprocal of 0.577, which is found on *CB*, using the curve *LMN*, on *AB* at the top. This is indicated by arrows and the value found is 1.73.

Secant—Since *sec* 30° equals 1/ *cos* 30°, read the reciprocal of 0.866 as found for *cos* 30 deg. on *CD*, using the reciprocal curve on *DA* to the left. This is indicated by arrows and the value thus found is 1.15, which is the natural secant of 30 deg.

Cosecant—Since *csc* 30° equals 1/ *sin* 30°, read the reciprocal of 0.5 as found for *sin* 30° on *CB*, using the reciprocal curve on *AB* to the top. This is indicated by arrows and the value thus found is 2, which is the cosecant of 30 deg.

For angles over 45 deg. the functions are found as follows: Read the cotangents directly down to *CD* and the tangents, using the curve *LMN* on *DA* to the left; the other functions are found in the same manner as those of angles under 45 deg.

The Trigograph has been copyrighted by A. D. Burton, 214 North Mayfield Ave., Chicago, Ill., and is furnished in 9x12-in. and 22x24-in. sizes.

Heating Engineers Hold Annual Meeting

On Jan. 20, 21 and 22 the American Society of Heating and Ventilating Engineers held its annual meeting in the Engineering Societies Building, New York City. A number of interesting papers were presented and there was a large attendance to take part in their discussion.

On Tuesday the first session was called to order at 2 p.m. by President Hale. Routine business, committee reports and reports from the chapters occupied the time. The report of the committee on testing house-heating boilers, which was presented at Buffalo last July, had been printed and was read. It included instructions on apparatus and instruments, rules for conducting evaporative tests, suggestions for starting and stopping and a formula by which to rate a boiler. Written discussion on the report was requested, and a committee was appointed to confer with manufacturers, architects and the National Association of Master Steam and Hot-Water Fitters for the purpose of drawing up standard specifications for this type of boiler.

On Tuesday evening, E. Vernon Hill gave a report of the work of the ventilation division of the Chicago health department. The model ventilation law, got up by the committee on compulsory legislation, created extended discussion which was carried over until Wednesday morning, and was finally disposed of by appointing a committee to consider the objections offered. This committee, reporting Thursday afternoon, suggested a careful revision of the report and specified some of the more important requirements for the guidance of the committee having the matter in hand. A motion-picture lecture on the manufacture of steel pipe from the mining of the ore to the finished product was the feature of this session.

Wednesday afternoon the tellers of election reported the following officers for 1914: President, S. R. Lewis, Chicago; first vice-president, E. F. Capron, Chicago; second vice-president, D. D. Kimball, New York; treasurer, J. A. Donnelly, New York; directors, John F. Hale, Camden; W. W. Macon, New York; John R. Allen, Ann Arbor; F. T. Chapman, New York; J. M. Stannard, Chicago; Frank G. McCann, New York; F. I. Cooper, Boston and H. M. Hart, Chicago.

The first papers of the meeting were those of A. M. Feldman. One on "A Ward-cooling Plant in a Hospital" described an experimental installation at the Mt. Sinai Hospital in New York City. Outdoor air is forced by a motor-driven fan through a water chamber in which the water is cooled by brine coils. From this chamber the air is forced through an upper chamber containing additional brine coils and thence through short ducts into two small wards, where the cooled air enters near the floor level. The average temperature in the wards for 42 days was 69 deg. F., when the outside temperature averaged close to 80 deg. On one occasion the ward temperature reached 74 deg., but at this time the temperature of the street rose to 93 deg. Humidity readings taken on 25 different days averaged 60 per cent.

The second paper described the equipment for "Cooling Two Rooms in a Country Residence." An insulated box provided with two brine tanks containing ammonia coils was placed in the attic. The top of the box was connected with a short duct to the roof dormer for taking in fresh air, and from the ends near the bottom two galvanized-iron ducts were connected to the ceiling registers of the two rooms. Fresh air enters the top of the box, is cooled, and then drops by gravity through the registers to the floors of the rooms. It escapes through partially opened windows. A motor-driven 5-ton ammonia compressor is part of the equipment, which maintains a temperature 6 deg. lower than out of doors. A number of committee reports followed, the first being on standardization of the use of the pitot tube. The committee outlined a practical method, explaining how to make a pipe traverse and giving constants by which to multiply the velocity pressure taken at the center for approximate results. For pressure readings of one inch or less the use of an Ellison Differential draft gage graduated to hundredths was recommended and for pressures over one inch an Ellison gage or a U tube graduated to tenths.

"Heating Practice in Sweden," by H. T. Theorell, was the next paper. The author gave the status of the art in his country, outlining the relations between the manufacturer, the contractor and the engineer and the comparative use of hot air, water and steam. Broadly, Swedish practice has developed along the same lines as in Germany.

An interesting paper by H. W. E. Muellenbach, telling what the Germans are doing in the heating line, and another on French practice by Gustave Devesson, were read on Thursday. These three papers will be given attention in later issues.

Prof. John R. Allen's paper on "Coefficient of Heat Transmission in a Pressed Steel Radiator" was read by W. F. Verner. From comparative tests of cast-iron and sheet-steel radiators it was shown that the coefficients of heat transmission were approximately the same, and that the relative speeds of heating up a room were not appreciably different, although the condensation for the first 20 min. was considerably more in the cast-iron radiator, the excess being caused by the greater weight of metal. The paper would have been more instructive if steam had been taken from a limited supply such as a boiler which will supply but little more than the heat loss from the room or building in zero weather. This is the condition found in practice, and in such a case the time element would have been in favor of the pressed-steel radiator.

More committee reports, and in particular one by D. D. Kimball on the work and the equipment of the New York State Ventilation Commission which has been provided a fund of $50,000, ended the session.

On Thursday morning C. M. Ripley read his paper on "Life of Building Power Plants," in which he cited a number of plants in New York City, which have been in service from 15 to 31 years. Basing depreciation on the life of the plant, the summary of the paper showed an average of about 4 per cent., and in one case it was only 1½. R. P. Bolton objected to this method of rating depreciation. It is not a question of how long a machine will run, for it loses its value just as soon as some other machine of greater efficiency is on the market. A certain firm out West had scrapped machines only 5 years old. It is possible to find plenty of old engines, but the space they occupy and the cost of running does not compare favorably with present-day equipment or with the cost of current purchased outside. For commercial depreciation, a life of 20 years is too long; 15 years is more nearly right, and in some cases less. Other discussion, foreign to the subject, followed, in which Mr. Bolton showed his interest in the central station, while Mr. Ripley naturally favored the isolated plant.

Another paper by John R. Allen on the "Effect of Time in Determining Radiation" was next read. The author considered four principal factors: The heat required to warm the interior structure such as windows, walls, floors and furnishings; that to warm the air in the room, and that to take care of the losses through the walls and windows, which included diffusion and floor and ceiling losses. In the paper, mathematical expressions were developed for these factors and curves were included showing the length of time required to heat a building of certain dimensions and construction with varying amounts of radiation. In the discussion it was pointed out that humidity, the effect of the wind and of the sun's rays had been neglected by the author. The contents of some buildings also have a decided effect on the time of heating up, and so has the apparatus itself when supplied with the limited amount of steam common in practice. Window leakage, depending on the construction, also affects the time element.

"Flow of Steam in Pipes," a paper doing credit to the author, H. W. Verner, was then presented in abstract. Fundamental principles relative to steam led up to a consideration of the fundamental equations of various authorities on the subject. These equations were put into suitable form for the plotting of logarithmic charts appearing in the paper. Pressures between atmospheric and three pounds were considered. The charts dealt with sizes of pipe from ⅜ to 15 in. in diameter, and much of the data on B.t.u. capacity of pipes and pressure drop were given in tabular form.

Thursday afternoon was devoted to the paper on "Heating Practice in Germany" previously mentioned, topical discussions on the fractional valve and experience in heating concrete construction. When radiation proved insufficient in concrete buildings, it was too often the custom to install more heating surface instead of spending money on window treatment and the provision of a false ceiling to prevent excessive radiation from the roof. For steam systems, down feed was advised and the provision of doors to cut off the suction inside the building was worthy of attention. Changes in the constitution, the installation of the newly elected officers and other matters of business brought the last session to a close.

Sightseeing trips about the city had been arranged to entertain the ladies, and the feature for all was the banquet held on Wednesday evening in the Hotel Martinique. Nearly 200 were in attendance and they listened with interest to John F. Hale, toastmaster, and a number of other speakers.

⁂

Marine Engineers' Washington Convention

The National Marine Engineers' Beneficial Association of the United States of America convened in its thirty-ninth annual session at 10 a.m., Jan. 19, at the Raleigh Hotel with the following officers: William F. Yates, national president; George H. Bowen, second national vice-president; Charles N. Voxburgh, third national vice-president; George A. Grubb, national secretary; Albert L. Jones, national treasurer. The following were appointed as the committee on credentials: Thomas C. Moore, E. C. Mausshardt, E. E. Morris, E. M. Roberts, James W. Hare.

At 11:30 a.m., National President Yates introduced Rear Admiral Griffin, Engineer-in-Chief of the U. S. Navy, who addressed the members. Captain Charles A. McAllister, Engineer-in-Chief of the U. S. R. C. S., followed in a humorous vein and advised regarding the status of the engineering profession. Honorary membership was conferred upon Rear Admiral Robert Griffin.

The convention was opened by National President Yates. The privilege of addressing the convention was accorded Andrew Furuseth, president of the International Seamen's Union, and Mr. Ross, president of the National Marine League. A recess was then taken until 5 o'clock.

The reports of the vice-president, the secretary and the treasurer were read and approved. Invitations were extended to hold the 1915 convention in San Francisco, Atlantic City, New York, Chicago, Wilmington, Galveston, and Los Angeles. At 5:18 p.m., adjournment was taken.

At 10 a.m., Jan. 20, Andrew Furuseth was introduced and presented a resolution which was referred to the committee on legislation.

President Yates then read his decisions given to the various associations during the past year. He appointed Representatives Jones, Kelly and Yates, as a committee to wait on Assistant Secretary Sweet regarding revision of the inspection service. The meeting then adjourned until 2 p.m.

At the afternoon session President Yates read correspondence of importance regarding high steam on government boats from Chief Engineer W. B. Ladue.

At the third session, Jan. 21, President Yates introduced Mr. Ross, president of the National Marine League. His address was referred to the committee on the good of the order.

At the afternoon session the following officers for the year 1914 were elected: National president, William F. Yates; first national vice-president, E. C. Mausshardt; second national vice-president, George H. Bowen; third national vice-president, Charles N. Vosburgh; national secretary, George A. Grubb; national treasurer, Albert L. Jones. Advisory board, Representatives Delahunty, Brown and Goelet. Trustee, Representative Crum.

The entertainment features were thoroughly enjoyed. These were a theater party on Monday night for everybody and one exclusively for the ladies on Wednesday night, and autos took several sightseeing parties about the city. Of course, the smoker tendered the engineers by the Supply Men's Association was the main event, and was heartily enjoyed by all. Among the guests were prominent Arm and Navy officers. As for entertainers the New York "Bunch" and others equally well known kept things moving throughout the evening.

The fortieth convention will meet in Washington, D. C., the week beginning Jan. 18, 1915.

⁂

Peculiar Traffic Delay—The high wind was the cause of the coldness and slowness of the cars on the elevated, subway and surface lines in New York City during the rush hours, Tuesday evening, Jan. 13. Coming at low tide, it so much further lowered the water in the East River that the intake pipes to the condensers in the Waterside station were marooned. This made it necessary to so far reduce the power output that the cars had to turn off their electric heaters to save power and run at about half speed. It was two hours before both full speed and heat could be restored.

NEW PUBLICATIONS

FOWLER'S MECHANIC'S AND MACHINIST'S BOOK AND DIARY, sixth annual edition; by William H. Fowler. Published by the Scientific Publishing Co., Manchester, Eng. Size 3⅜x6 in.; 476 pages. Paper. Price, sixpence.

The sixth annual edition of this book, intended as a synopsis of rules for mechanics generally, is now available. Some data have been added.

FOWLER'S MECHANICAL ENGINEER'S POCKETBOOK. By William H. Fowler; sixteenth annual edition. Published by the Scientific Publishing Co., Manchester, Eng. Size 3⅜x6 in.; 576 pages. Cloth, 1s. 6d.; leather, 2s. 6d.

The sixteenth annual edition of this English mechanical engineer's pocketbook is about the same as other editions, with a little additional data compiled to bring the volume uptodate.

ARITHMETIC OF THE STEAM BOILER. By Charles J. Mason; published by the McGraw-Hill Book Co., New York. Cloth. Size, 4½x6¾ in., 219 pages. Price, $1.

This volume is the latest addition to the "Power Handbooks." It is esentially a reference book showing various applications of arithmetic to steam boilers, particularly to calculations of the strength and efficiencies of joints. The book does not aim to teach the elements of arithmetic.

The volume is in three parts, the first dealing with calculations involving the strength of miscellaneous seams, the size of feed pipes, chimnies, etc. The third contains abstracts of the rules of the United States Board of Supervising Inspectors of Steam Vessels and of the Massachusetts Boiler Rules. Many useful tables are given in this part.

The book should be well received by power-plant engineers.

THE FITTING AND ERECTING OF ENGINES. By C. Leslie Brown. Published by Elmot & Co., Limited, 65 King Street, Manchester, Eng. Cloth; 153 pages, 5¼x8½ in.; 114 illustrations. Price 3/6 net (87c.).

This book, a compilation from a series of articles that appeared originally in the "Mechanical World," is written in plain shop language for the express purpose of instructing and assisting young or inexperienced fitters and erectors in practical work both in the shop and in the field.

The author starts with a comparison of modern shop practice with that which obtained only a few years ago, after which he follows the course of a modern high-speed engine in detail from the foundry and forge shop through the processes of fitting and erecting on the shop floor.

In its 23 chapters the book covers the field indicated in the title, and while much of the matter is in the nature of editorial observation, no words are wasted on irrelevant subjects.

Alignment, the scraping and adjusting of bearings, metallic packing, forced lubrication, high-speed and Corliss engine valve setting, the care and handling of machine parts and rigging and the general behavior of the workman both in the shop and field are among the many subjects treated.

The work is English and tells of English practice in English shops, but it is well worth the careful study of any mechanic engaged in fitting and assembling engine parts in the shop or erecting the complete machine where it is to run, or of foremen in charge of such work.

HEATING SYSTEMS AND THE DESIGN OF HOT WATER AND STEAM HEATING APPARATUS. By F. W. Raynes. Published by Longmans, Green & Co., London and New York City. Cloth; 328 pages, 5½x8¾ in.; 158 illustrations, tables. Price, $3.50.

As indicated in the title, the book takes up both steam and hot-water heating. Under the latter heading, gravity and forced circulation are covered, and under the former both low-pressure live-steam and vacuum systems of heating are given attention. Heating surfaces, heat loss from buildings and the sizing of pipes are naturally included and the last two chapters of the book are devoted to boilers and the temperature control of buildings.

With some revision, the book would be excellent for student use. The chapters on vacuum steam heating are original and give thoroughly the limitations of such systems. The diagrams of different systems of piping are clear, and the method of illustration is to be commended. To the steam end of the book there can be no serious objection, unless possibly to the charts showing the flow of steam in pipes. In some of these charts one division has been made equal to 2,000,000 B.t.u. per hr., or about 60 boiler-horsepower. Accuracy would call for a chart on a larger scale.

The chapters on hot-water heating, and especially those relating to forced circulation, are seriously at fault, and will require considerable revision to bring them up to a standard comparable with the balance of the book. Much of the subject matter is incorrect, or at least misleading, and there is objection to the formulas used.

In stating the respective merits of steam and forced hot water for district heating, the author asserts that steam is more advantageous for industrial centers due to its possible use for manufacturing purposes. It is bad practice to utilize the distribution mains of any heating system, whether steam or water, to convey heat for manufacturing purposes, as the heating plant is inoperative in summer, and the mains are then too large and consequently inefficient for the other service. Such a system should be operated on its own mains properly proportioned for the work.

The author lays great stress on the cost of pumpage in forced hot-water heating. This depends on the size of the installation. If the exhaust steam from the pump is utilized, all the heat will be returned to the system, but the operation will be live steam to that extent. In a properly designed system the cost of pumpage should be less than in most vacuum steam systems. The reader is advised that fittings of the O. S. type should be used sparingly in gravity circulation due to the resistance introduced, but that on forced circulation there is less objection to their use. It is difficult to see how these statements can be reconciled as the same objection should hold with greater emphasis for forced circulation.

Except in the case where the heating load exceeds the amount of exhaust steam available, the chapter on forced circulation dealing with the use of exhaust steam from condensing engines and turbines is impractical. With the arrangement shown by the author, the vacuum would be variable and not much more than sufficient to relieve the engine of pressure above atmospheric. This condition would be fatal to the economical operation of a steam turbine. The illustration showing a hot-water system for high buildings is practically identical with the cut which appeared in "Power," Dec. 19, 1911, with the exception that the condensing feature is eliminated. This removes the advantage of hot-water heating in this class of work as the engine load the greater part of the time requires steam in excess of that necessary for heating. Unless vacuum were carried, reducing the steam rate on the engine, there would be no reduction in the total fuel due to a more economical heating system.

In another illustration a condenser is shown, but the arrangement would be impractical with several machines, some operating at full vacuum and others under partial vacuum on the heating. If all machines were operated on reduced vacuum for the heating, the economy of the plant would be considerably lessened.

The suggestion on operating a live-steam heater in conjunction with an exhaust heater is bad practice, as one may operate to cool the water heated by the other. When the live-steam heater is used the engines should be exhausting at atmospheric or back pressure. The method of regulating the output of the heater by submerging the tubes in the condensation is all right for the live-steam heater but unnecessary in an exhaust heater.

The hydraulic formulas for the capacity of pipes for both gravity and forced circulation do not check with those of the best authorities. The discharge for a 3-in. pipe under a head corresponding to a velocity of 10-ft. per sec., should be 1900 lb. per min. The author's formula gives 1500 lb., which is more than 20 per cent. less. For each size of pipe the same factor is used for all velocities, which, when reduced to the same basis, is very different from any given by Fanning for the usual velocities.

In the charts giving the capacities of pipes for hot-water heating, only pipes up to 4 in. in diameter are included. As forced circulation is necessarily used on plants of large capacity in which the mains are seldom as small as 4 in., the charts are of little use. To be of practical value, they should be extended to include pipes up to 12 in. in diameter. The use of hydraulic gradients as abscissas is of no particular advantage, as computation of the loss in head is required for each reading.

In describing shunt circuits, the author states that the flow through the shunt will be inversely proportional to the resistances in the branch and main within the shunt. The resistances, between the points of joining, of the shunt and of the main are precisely the same, and this is true of the loss of head in each circuit. According to the author's statement there would be equal flow, which, of course, is not true. The velocity, diameters and lengths are such as to make the losses in head the same between the two points in question.

It is apparent that the author is not familiar with hot-water heating, and has failed to keep pace with the advance made during the last few years in this country. It is only fair to state, however, that, with one or two exceptions, there is no book which adequately treats this branch of the heating art. It is not surprising, then, that the present book is also lacking in this respect.

The author and title catalog for 1914 of the Public Service Corporation of New Jersey has been published. This preliminary list will be followed by a classified catalog. The library has proved its wide usefulness to its patrons and brought a broad range of books and other publications within their reach. Mrs. Helen I. Brewster is the librarian.

BOOKS RECEIVED

ENGINE ROOM CHEMISTRY. By August H. Gill. McGraw-Hill Book Co., New York. Second edition, cloth, 211 pages, 4½x7 in., illustrated, tables. Price, $1.

INVESTIGATING AN INDUSTRY. By William Kent. John Wiley & Sons, Inc., New York. Cloth, 126 pages, 5x7½ in. Price, $1.

HANDBOOK OF ELECTRICAL METHODS. Compiled from the Electrical World. Published by McGraw Hill Book Co., New York. Cloth; 285 pages, 6x9¼ in., illustrated. Price, $3.

FOWLER'S MECHANICS' AND MACHINISTS' POCKET BOOK AND DIARY FOR 1914. By Wm. H. Fowler. Scientific Publishing Co., Manchester, England. Paper; 476 pages, 3¾x6 in., illustrated, tables. Price sixpence.

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK FOR 1914. By Wm. H. Fowler. Scientific Publishing Co., Manchester, England. Cloth; 576 pages, 4x6 in.; illustrated; tables. Price 1s. 6d.

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR BOOK FOR 1914. Emmott & Co., Manchester, England. Cloth; 443 pages, 4x6¼ in.; illustrated; tables. Price 25 cents.

THE "MECHANICAL WORLD" ELECTRICAL POCKET BOOK FOR 1914. Emmott & Co., Manchester, England. Cloth; 4x6¼ in.; illustrated; tables. Price, 25 cents.

Civil-Service Opportunities

COMPETITIVE EXAMINATIONS *for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commissions. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.*

Situation for Pumpman—The Philadelphia Civil Service Commission will hold an examination, Feb. 11, for the position of pumpman in the electrical bureau, department of public works. Salary, $3 a day. Address the Civil Service Commission, room 875, City Hall.

Situation for Draw-Bridge Operator—The Philadelphia Civil Service Commission will hold an examination, Feb. 13, for steam draw-bridge operator, a position in the Bureau of Highways, Department of Public Works. Salary, $1000. Address the Civil Service Commission, room 875, City Hall.

SOCIETY NOTES

Francis S. Peabody, president of the Peabody Coal Co., Chicago, Ill., recently gave a lecture before the College of Engineering of the University of Illinois on "The Mining and Utilization of Illinois Coal." The lecture was illustrated with the first successful motion pictures taken underground, and they gave a vivid idea of the actual conditions met in coal mining.

The Pittsburgh chapter of the National Association of Stationary Engineers held its first winter educational meeting Jan. 12, at which R. B. Ambrose, of the Carnegie Institute presided. H. A. Hoffman, of the General Electric Co., read a paper on "Steam-Flow Meters," which was followed by a general discussion of the device used to measure steam in its different uses.

On Saturday evening, Jan. 17, the Engineers' Blueroom Club held its annual ladies' night and installation of officers at the New American House, Boston, Mass. Over 250 attended. Following the dinner, there was a most enjoyable cabaret show and an informal dance was given in the old Colonial dining room. The officers for 1914 are, President, Peter H. Bullock, chief engineer, Massachusetts Reformatory, Concord; vice-president, Merle W. Eastman, chief engineer of the Dorchester power station, Boston Electric Ry. Co.; secretary, Thomas A. Ray, chief engineer, Reece Building, Boston; treasurer, Thomas B. Constant, mechanical engineer, Johns-Manville Co.; sergeant-at-arms, Ernest E. Erickson, chief engineer, Harvard Medical School. The members of the executive committee are the president, vice-president, secretary, treasurer and John F. Cochran, Charles B. Klingeman, Myles M. Lab, Ernest R. Stevens and Ernest A. Ford. The installing officers were Past President Herbert E. Stone and George W. Knowlton. On behalf of the club, Past President Stone presented Past President Campbell a gold and diamond jewel, and Messrs. Trude, Allen and Kloss bouquets of cut flowers for their good work on the entertainment committee. The club has a membership of 560.

PERSONALS

Otto Dieckmann, Jr., manager of the Kewanee Boiler Co., Twelfth and Olive Sts., St. Louis, Mo., was elected trustee in bankruptcy for the Kauffman Heating & Engineering Co., 2109 Olive St.

Harry B. Allen, formerly with the Ashton Valve Co., has become affiliated with Thomas Foster & Co., factory representatives, 900 Michigan Ave., Chicago, Ill., in the capacity of vice-president and treasurer.

S. Rosenzweig, until recently mechanical engineer with the Erie City Iron Works, Erie, Penn., has joined the York Manufacturing Co., with whom he will act in the capacity of consulting engineer in the steam-engine department.

Prof. J. M. Bryant, of the department of electrical engineering of the University of Illinois, has recently been employed by three cities of Illinois, Jacksonville, Kewanee and Lewistown, as consulting engineer in connection with municipal electric-lighting work involving both technical and economic problems.

OBITUARY

EDWIN EMERSON NOLAN

Edwin Emerson Nolan, head of the materials disposition department of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Penn., died at his home 517 Center St., Wilkinsburg, Penn., on Tuesday, Jan. 13. He was born in Chicago, Aug. 10, 1857.

Mr. Nolan began work with the Westinghouse Electric Co. in 1887 just about the time it began operations on Garrison Alley in the city of Pittsburgh. He was subsequently made superintendent of the Allegheny factory of the company and as such had charge of building the first alternating-current generators for the Niagara plant. He retained this position until the factory was converted into a foundry.

In 1898 Mr. Nolan was sent to France to establish a factory at Havre, where he remained until 1902. After his return to the United States, and on account of his familiarity with Westinghouse apparatus, he was placed in charge of the materials disposition department, which position he held until his death.

Mr. Nolan was a mechanical engineer and an inventor of considerable ability; one of his inventions is now in use on street railway motors.

He was noted for his thoroughness in all undertakings, and was an exceedingly reliable and conscientious employee. His kindly disposition and method of dealing with men endeared him to a large number of acquaintances which he had made in this country and in many foreign countries.

Mr. Nolan leaves a widow and two sons and two daughters.

⁂

A Red Light Signal for the Hoisting Engineer is provided at the Kennedy mine on the north Cuyuna range, to serve as a memory help. A red electric bulb is placed in front of the engineer's stand in line with the center of the drum. At the end of a trip the reverse lever is supposed to be always thrown over. This operation flashes the red bulb and thus impresses itself on the engineer's memory. It is well known that overwinding accidents are often caused by the fact that the engineer thinks he has thrown his reverse for the next trip, when, in fact, he has not, so that on starting he pulls the conveyance at the shaft collar up into the sheave. The use of a simple device like this ought to help to prevent such accidents.

⁂

Concrete Resisters for lightning-arrester service, as used by a Georgia power concern, are made of concrete blocks 4 ft. long and 1 sq.ft. in cross-section, set upright at the point of installation. Two squares of bronze or copper mesh cast into the blocks near either end connect with the source of energy and with a ground wire.

POWER

Vol. 39 NEW YORK, FEBRUARY 10, 1914 No. 6

Your Employer Will Know

DO you always manage to get busy on the approach of your employer? Do you ever refuse to work overtime and inconvenience yourself when it would mean a saving for your employer, on the ground that he would never know of it and you would get no credit for so doing?

Do you ever refuse to lend a helping hand to your brother in another department in emergencies, on the ground that the company would not thank you and that it can afford to put on extra help?

Concerning the first question, your employer knows whether or not your plant is operating satisfactorily, and if it is, and you have time to sit down and read or swap yarns with your associates, there is no reason to break and run like frightened sheep at his approach. When you do he must conclude either that you have been neglecting something or that you consider him your avowed enemy, both alike displeasing to any fairminded employer. If he is not such a one, then keep busy all the time (if that is what he desires) or seek another position, but never show any more signs of diligence in his presence than you would otherwise.

Regarding the other two questions, do not get the idea that your employer will never know of the extra things you do, large or small. Even though he did not, doing them will do you no harm but, on the contrary, you will gain experience; your conscience will feel satisfied because you turned a loss into profit, or made a friend by lending your assistance in time of need, and last but not least, you will form a commendable habit that will redound to your credit and benefit. A spirit of willingness to do, regardless of direct reward or appreciation, is the proper one and is bound to make you a better man and a better master of your profession.

[*Contributed by Joseph Stewart, Hamilton, Ohio.*]

Model Mixed-Flow Steam-Turbine Plant

By Warren O. Rogers

SYNOPSIS—Exhaust steam from 4000 hp. in reciprocating engines and five steam hammers, varying in size, is used to operate three 1250-kv.-a. horizontal steam-turbine generators, at 16 lb. pressure, absolute. The electrical energy developed from steam, which was formerly wasted, operates a maximum of 114 motors, a total of 2800 hp. The turbines run condensing. A high-pressure, 100-kw. turbine unit supplies electrical energy during periods when the larger units are not operating.

* * *

Since the founding of Henry Disston & Sons, Inc., Philadelphia, Penn., in 1840, many thousand pounds of water in the form of exhaust steam has been allowed to go to waste after passing through steam hammers and rolling-mill engines, as was, and still is, the practice in such works. From time to time new buildings were erected, and more machinery called for additional steam consumption, until the Disston works are now the largest of their kind in the world.

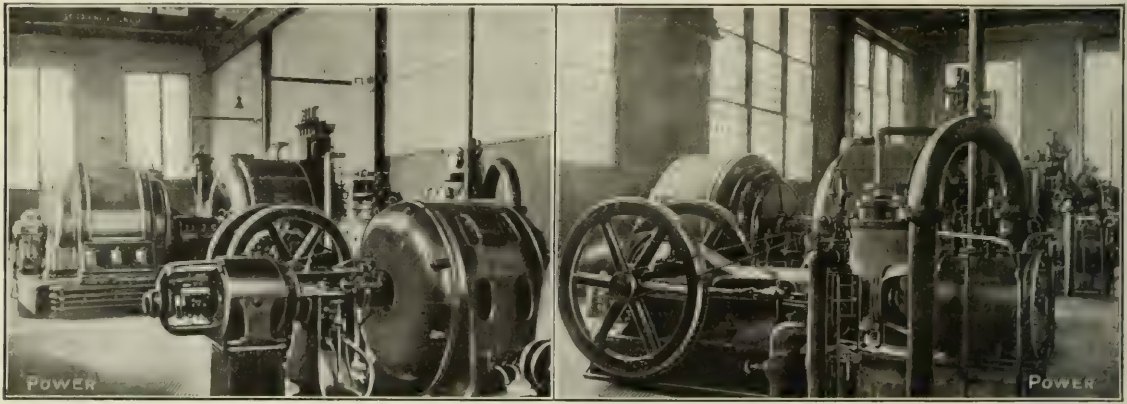


Fig. 1. Three 1250-Kw. Mixed-Pressure Steam Turbines

At present, the mill steam equipment consists of five steam hammers, varying in size, capable of striking blows of from 50 to 4500 lb., and 13 rolling-mill steam engines, with a total capacity of 4000 hp. The exhaust steam from these units approximates 60,000 lb. per hr., which formerly escaped to the atmosphere.

This, however, was before the mixed-pressure turbine had been developed. Now, all exhaust steam is piped to a receiver, but about 40,000 lb. per hr. is used in the turbines, which are installed in a separate power plant; the balance of the steam escaped to the atmosphere.

Turbine Units

In Fig. 1 is shown the three main, 1250-kw. mixed-pressure turbines, driving 1250-kv.-a. alternating-current generators at 1800 r.p.m. and delivering electrical energy at 2300 volts. The turbine room adjoins one of the rolling-mill buildings and is lighted by windows at both ends and the outside wall, as shown. The cream-colored walls also add to the lighting effect, and the dark-brown wainscoting gives a clean, attractive appearance.

The turbine units are placed crosswise, with the steam end next to the brick wall dividing the turbine room from the rolling mill. At the rear end of the room is a 100-kw. high-pressure steam turbine which generates 2300-volt alternating current at 3600 r.p.m.; a self-contained exciter set is mounted on the generator end of the shaft. At the same end of the room there are two direct-current exciter sets, each of 75-kw. capacity, at 125 volts. A 125-hp. induction motor drives one generator at 1200 r.p.m.; the other is driven by a 75-kw. single-stage horizontal turbine at 3300 r.p.m. This turbine runs noncondensing, but it is used only when all of the main turbines are shut down, and the small high-pressure turbine is not operating. This condition, however, has never obtained since the plant was put in operation on Apr. 21, 1913.

The slate switchboard consists of 15 panels; six are for controlling the motor circuits, four are generator panels, three are for the exciter control, one is devoted to instruments and one to control the induction-motor exciter unit. A 20-ton Niles crane travels the length of the turbine room, the floor of which is made of concrete.

Condensers

The four surface condensers are in the basement, directly beneath the turbine units. The three large condensers contain 5000 sq.ft. of 1-in. tubing. Circulating water is supplied to each large condenser by a 12-in. volute pump, driven by a 9x7-in. vertical steam engine, Fig. 2. At the time of the writer's visit the temperature of the circulating water was 54 deg. F.; that of the discharge water never differs more than 7 deg. F. A vacuum of 28 in. is carried. The dry-air pumps of each condenser, of the horizontal reciprocating type, are placed alongside the turbine on the turbine-room floor. A small surface condenser, Fig. 3, containing but 300 sq.ft. of cooling surface, is also in the basement and serves the small 100-kw. turbine. The condenser is fitted with a reciprocating circulating-water and air pump with cylinders 6, 8 and 8 by 10 in. in size.

Each of the large condensers has a hotwell which is attached to the bottom of it. The water of condensation is taken from each hotwell by a 6 and 5¾ by 6-in. duplex pump and, after passing through a heater, is discharged to the boilers some distance away. This condensate at the present load on the turbines is approximately 40,000 lb. per hr., which represents the amount of steam that is now utilized in producing electrical energy from steam that was formerly wasted. Even under existing conditions 20,000 lb. of steam goes to the atmosphere, but some of it will be used in heating the buildings as soon as a suitable system has been installed.

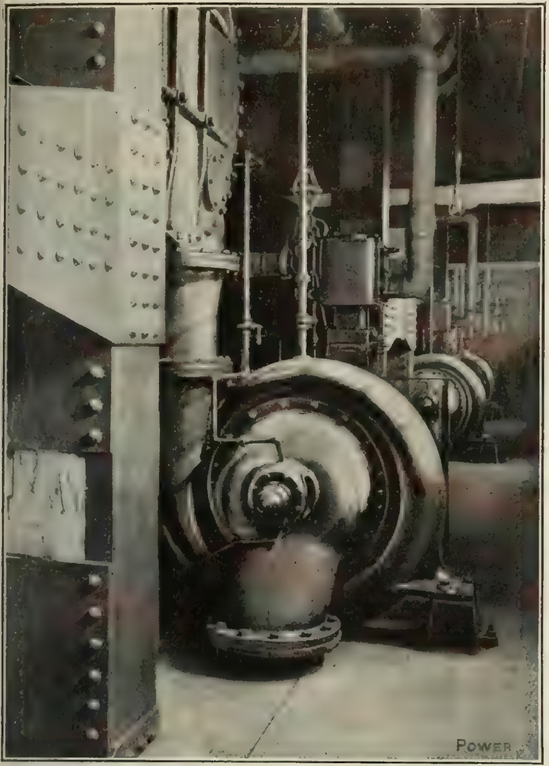


Fig. 2. Engine-Driven 12-In. Volute Circulating Pumps

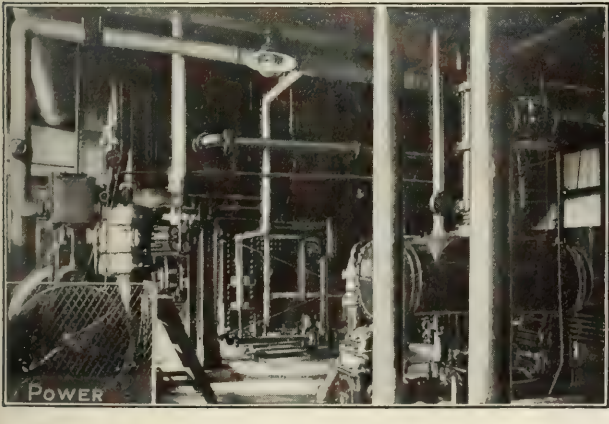


Fig. 3. Partial View of the Surface Condensers in the Basement

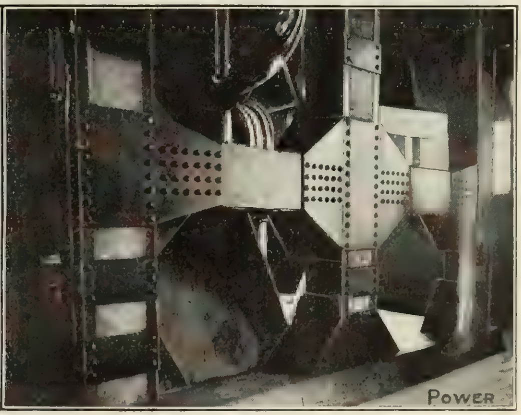


Fig. 4. Turbine Foundation of Channel Iron and Concrete

A novel method of supporting the turbines has been employed. Under each unit eight concrete piles were set in the earth, and upon them a concrete block 5 ft. thick was placed. Upright pieces of channel iron rest on the concrete base and are filled in with concrete, as shown in Fig. 4; Fig. 5 is a detailed drawing.

When the plant was first installed, air for cooling the turbo-generators was taken from outside the building, but the basement became exceedingly hot and air for the generators was later taken from the basement and discharged outside of the building, though galvanized-iron air ducts. The volume of air used for cooling each generator is 10,000 cu.ft. per min.

At one end of the condenser room is a motor-driven 42-in. propeller fan used to draw the hot air from the basement. Fresh air is admitted through screened windows at the opposite end of the basement.

All steam and exhaust lines are drained into traps in the basement, all placed on a projection built on the inside wall, as in Fig. 6. There are four large steam traps on the low-pressure steam lines, four on the exhaust-steam and four on the live-steam lines. These traps drain into a 3-in. main and the condensate is conveyed to a hot-water heater and then pumped into the boilers. This arrangement of the traps is ideal for they are placed where they are easily inspected and yet are above the floor level out of the way of the operators.

Piping

Exhaust steam is collected from the reciprocating mill engines, which are of various designs, by fitting each exhaust pipe with a three-way valve. When the valve is in one position the steam escapes to the atmosphere through the vertical pipe, shown in Fig. 7; when in the other, the steam passes to a main header leading to a receiver placed on the mill side of the turbine-room wall. The two exhaust-steam headers begin with an 8-in. pipe and increase in size as the exhausts from the various engines are piped into the main until the 28-in. receiver is reached. The two exhaust-steam lines enter the receiver from opposite directions, connecting at the two ends, as shown in Fig. 8.

To the upper side of the receiver a 28-in. back-pressure valve is connected, and is piped to the atmosphere. Back of the receiver is a live-steam main, which supplies each turbine with high-pressure steam through a 10-in. lead, when the exhaust-steam supply falls, as it does during the noon hour, when the rolling-mill engines are shut down. At the bottom of the receiver an outlet connection is piped to the main low-pressure main from which 16-in. branches lead to the three mixed-flow turbines. Each of these branch pipes contains a stop valve so that any one or all of the turbines may be cut out from the low-pressure header. These valves are operated by handwheels and horizontal shafts which extend through the turbine-room wall. The other end of each shaft is fitted with a bevel gear which meshes with a similar gear on a vertical shaft, a gear on the lower end of which meshes with a similar gear on the valve stem.

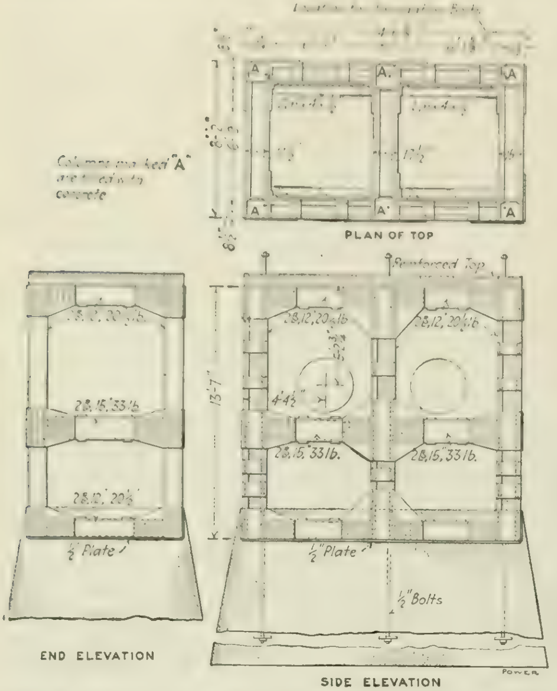


FIG. 5. DETAIL OF METAL CONSTRUCTION OF TURBINE FOUNDATIONS

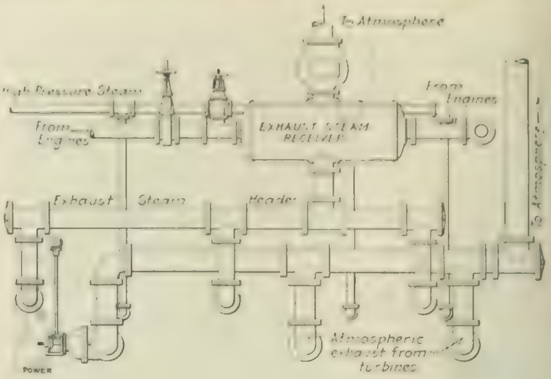


FIG. 8. RECEIVER, LINE AND EXHAUST-STEAM PIPING

In case it is desirable to operate the turbines noncondensing, a branch from the exhaust pipe of each is piped to a main header, below the low-pressure header, and rises vertically at one end to the atmosphere. The live-steam line to each mixed-pressure turbine is fitted with a strainer and a combined balanced trip and throttle valve. The turbines are also provided with a vacuum breaker. In Fig. 9 is shown a side elevation of the turbines and condensing units.

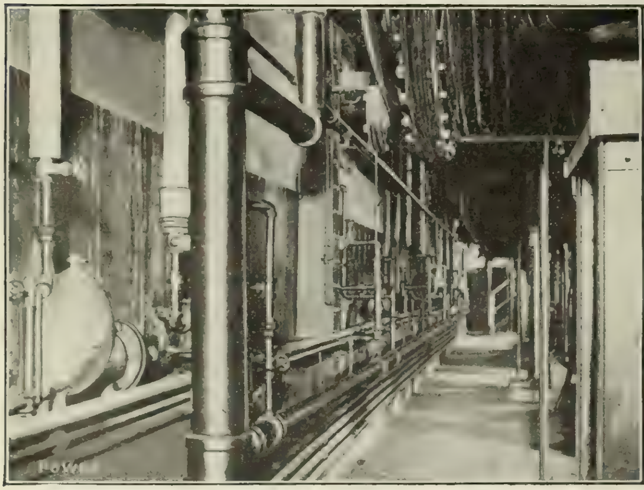


FIG. 6. ARRANGEMENT OF STEAM TRAPS AND DROP PIPING IN THE BASEMENT

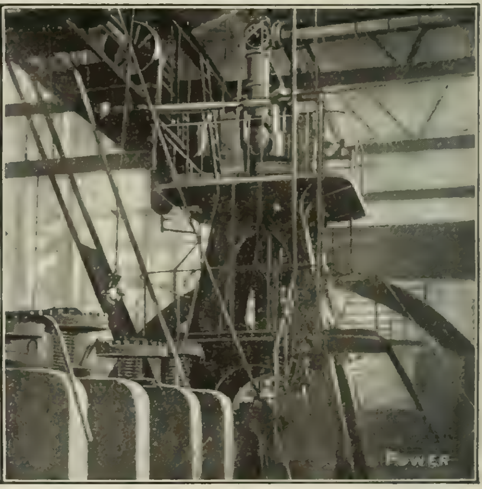


FIG. 7. THREE-WAY VALVE IN ENGINE EXHAUST PIPE

On each exhaust-steam line, close to each turbine, is a multi-flow valve, the purpose of which is to improve the operation of the turbines when using steam from the reciprocating units. The valve prevents a vacuum in the engine exhaust pipes, which would draw in air through leaky joints, piston rods or valve-stem packing, thus reducing the efficiency of the turbine by overloading the air pump. The valve is designed to close automatically as soon as the pressure in the exhaust line approaches the predetermined pressure, which in this installation is 16 lb. absolute.

The action of the valve backs up the flow of steam so that this pressure is maintained in the exhaust line, even though the pressure in the intermediate stage of the turbine falls to only a few pounds absolute, which will occur at partial loads. The valve disks are held to their seats by springs bearing on a movable pressure plate. By setting the plate at any point of its movement the pressure can be regulated by operating a handwheel on the outside of the valve.

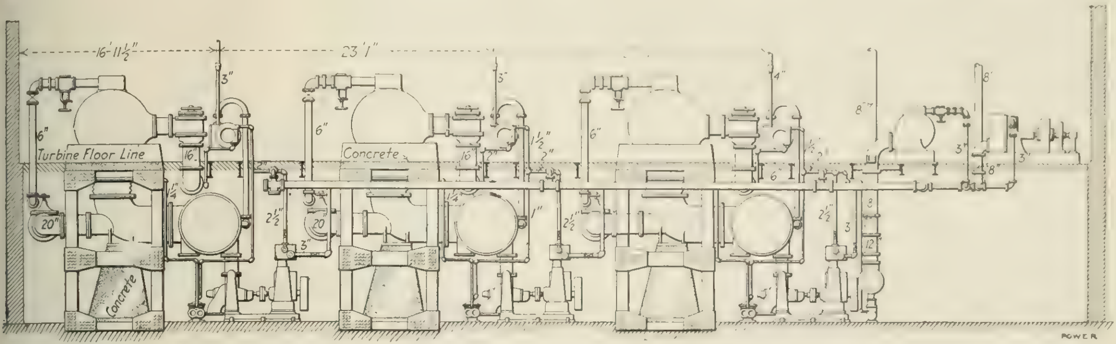


FIG. 9. END ELEVATION OF TURBINE AND CONDENSER UNITS

This valve controls the flow of exhaust steam from the engines so long as they are in operation. When the supply fails, the governor immediately brings into operation one or more live-steam inlet valves, admitting live steam to the high-pressure nozzles, which are automatically brought into action. By using special nozzles, the high-pressure steam is expanded from boiler pressure and, in these turbines, is used on the same bucket wheel with the low-pressure steam.

At the head of each turbine, on the wall, is a gage board on which is mounted a live-steam recorder, a high- and low-pressure steam gage, and a vacuum gage. These turbines generate electrical energy for 114 alternating-current motors through the works, or a total of 2800 hp. As the motors are not loaded to capacity, the average output from the turbines, of which two are in use at one time, is about 1000 kw.

PRINCIPAL EQUIPMENT OF THE HENRY DISSTON & SONS MIXED-PRESSURE TURBINE PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Turbines	Curtis	1250 kw	Main units	Mixed pressure, condensing, 1800 r.p.m.	General Electric Co.
3	Generators	Alt. current	1250 kw	Main units	1800 r.p.m., 2300 v., 272 amp., 60 cycle, 2-phase	General Electric Co.
1	Turbine	Curtis	100 kw	Auxiliary unit	3600 r.p.m., 100 lb. pressure, condensing	General Electric Co.
1	Generator	Alt. current	100 kw	Auxiliary unit	3600 r.p.m., 2300 volts, 22 amp.	General Electric Co.
1	Exciter	Self contained	4 kw	Auxiliary unit	3600 r.p.m., 125 volts, 56 amp.	General Electric Co.
1	Motor	Induction	125 hp	Driving exciter	1200 r.p.m., 2200 v., 60 cycle, 2-phase	General Electric Co.
1	Turbine	Curtis	75 kw	Driving exciter	3300 r.p.m., 100 lb. steam, noncondensing	General Electric Co.
2	Generators	Direct current	75 kw	Exciter generators	1200 r.p.m., 125 v., 600 amp.	General Electric Co.
3	Air pumps	Horizontal	8x20x12"	Large condensers	100 lb. steam	Alberger Pump & Condenser Co.
3	Condensers	Surface	5000 sq.ft. cooling surface	Main turbines	28-in. vacuum	Alberger Pump & Condenser Co.
1	Condenser	Surface	300 sq.ft. cooling surface	Small turbine	28-in. vacuum	Alberger Pump & Condenser Co.
3	Pumps	Volute	12"	Circulating water	Engine driven	Alberger Pump & Condenser Co.
3	Engines	Vertical	9x7"	Circulating pumps	100 lb. steam, direct connected	Alberger Pump & Condenser Co.
3	Pumps	Duplex	6x5¾x6"	Hot well water	Pumping water to boilers	Epping-Carpenter Co.
1	Fan	Propeller	42"	Basement ventilation	Motor driven	B. F. Sturtevant Co.
1	Switchboard	Slate		Electrical control		General Electric Co.
8	Traps	Ideal	Nos. 1 and 5	Condensate	Exhaust- and low-pressure lines	Tillotsen Humidifier Co.
4	Traps	Stickles		Condensate	High-pressure steam lines	Open Coil Heater & Purifier Co.
3	Valves	Trip and throttle		Turbine live steam line	Automatic	Schutte & Koerting Co.
3	Valves	Multiported	18"	Low-pressure turbine line	Automatic steam pressure control	Harrison Safety Boiler Works.
4	Valves	Vacuum breaker		Steam turbines	Automatic	Schutte & Koerting Co.

A few years ago the proposal to use exhaust steam for generating electrical energy would have been looked upon as folly. Even today, when the saving a mixed-pressure turbine will make is not understood, it is difficult to convince some engineers that the performance of this type of prime mover is not a fallacy in developing from 80 to 95 per cent. as much power as the original noncondensing engines are doing, without the expenditure of a pound of coal more or an investment for additional boilers.

The new power plant of Henry Disston & Sons, Inc., is a model of its kind and shows that the matter of design was thoroughly gone into before the installation was begun.

⁂

Power Site Reserve in Nevada—An order was recently issued by Secretary Lane, with the President's approval, creating a power site reserve in Boulder Cañon, on the Colorado River, 20 miles east of Las Vegas, Nev. It is expected the construction will develop 40,000 hp. at a minimum of expense. Secretary Lane announced that the classification of public lands as irrigable or nonirrigable, in conformity with the administration of the 320-acre homestead laws, was being accomplished satisfactorily. The Secretary has designated more than 900,000 acres in various Western States for entry under the terms of the act. The designations include 250,000 acres in Arizona, 5500 in California, 55,000 in Colorado, 27,000 in Idaho, nearly 200,000 in Montana, more than 8000 in North Dakota, 274,000 in Oregon, 5700 in Utah, 21,000 in Washington and 82,500 in Wyoming.

Absorption Dynamometer

A new type of absorption dynamometer has recently been placed upon the market by the Griffin Engineering Co., Ltd., of Bath, England. Its general appearance is shown in Fig. 3, while Figs. 1 and 2 illustrate special details of its construction.

The apparatus consists essentially of an inclosed conical-ended drum inside of which are adjustable brake shoes mounted on a central shaft, driven by the motor or other source of power to be tested, the friction between the shoes and the corresponding ends of the drum being regulated by an exterior handwheel in accordance with the load to be measured. The cooling is effected by introducing a small stream of water into the lower part of the drum, the water being brought in contact with the frictional surfaces by centrifugal action and discharged opposite the inlet after being swept entirely around the inner surface of the drum. The heat generated is thus removed with a minimum quantity of cooling water, which acts also as a lubricant between the frictional surfaces.

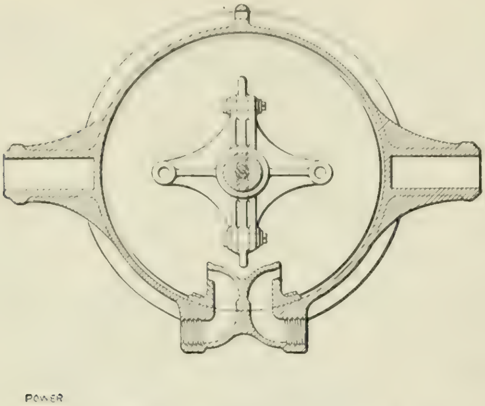


FIG. 1. VERTICAL SECTION ACROSS SHAFT

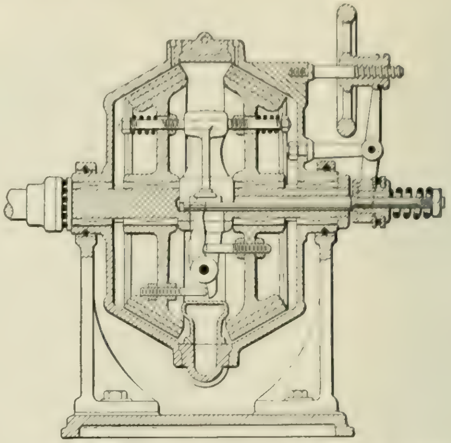


FIG. 2. VERTICAL SECTION THROUGH SHAFT

INCLOSED ABSORPTION DYNAMOMETER

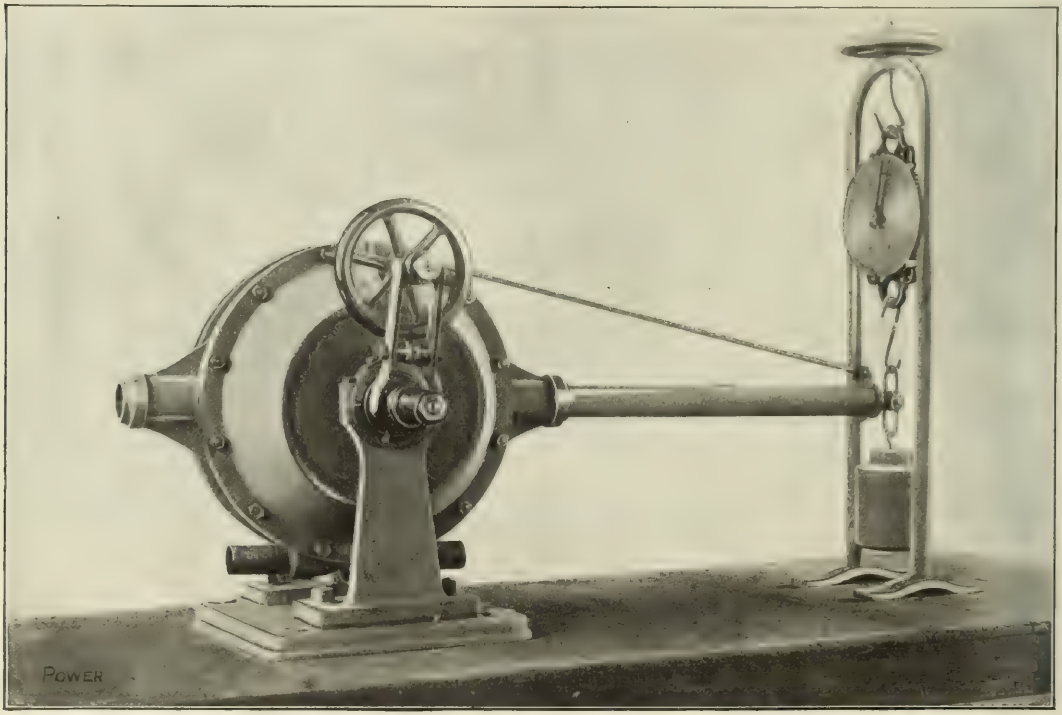


FIG. 3. INCLOSED ABSORPTION DYNAMOMETER MADE BY THE GRIFFIN ENGINEERING CO., LTD.

The drum is mounted on trunnions that oscillate on ball bearings. In this way negative resistance is nearly nil, and practically the whole of the turning effort may be considered as imparted to the brake shoes and transmitted directly to a dead weight by a lever attached to the drum. The readings are obtained as differences indicated on a spring balance as in Fig. 3, or if the effort is downward the readings may be taken directly from the spring scales without intervention of a dead weight.

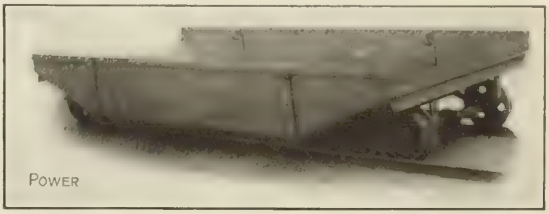
The friction of the brake shoes balances the torsional strain on the shaft and the entire apparatus may be adjusted to remain steady at all speeds and loads within its proper capacity. Shaft connections can be made direct either by means of solid or flexible couplings or through a universal joint or a flexible shaft, the latter being specially suitable for light powers and high speeds.

The apparatus is capable of being designed comparatively light in weight and there are no internal water pressures to be resisted or pumps to be operated as in the ordinary hydraulic water brake. As before stated, very little cooling water is required and this gives uniform lubrication of the frictional surfaces.

This form of friction-brake dynamometer appears to be specially suitable for long, continuous tests with either constant or variable loads. The water may be taken from any ordinary source of supply and may be conveyed away by hose, and conveniently discharged. There being but little opportunity of water leakage or the necessity for external lubrication, perfect cleanliness of the apparatus and its surroundings is secured. The apparatus is adaptable for either direction of rotation; and from its design, it appears to be an instrument meeting the requirements of motor manufacturers, electrical engineers, and for experimental work requiring an instrument capable of accurately measuring the power developed by high-speed motors in long runs.

Koppel Ash Car for the Power Plant

One way in which the efficiency of power-house operation can be increased is to provide means for handling ashes directly from ashpits without having to rake them out and then shovel them into a car or wheelbarrow.



Koppel Ash Car

The Calumet & Hecla Copper Mining Co. has recently been making extensive improvements in its power plant and the car shown in the accompanying illustration was designed so that it could be run underneath the boiler grates to catch the ashes as they drop from the grate. The car was built by the Orenstein-Arthur Koppel Co., Koppel, Penn.

When the car is full, it can be pulled out and run outside the boiler house to the ash dump or lifted by a crane and dumped into a standard-gage car for removal.

The body of this car is made of $\frac{3}{16}$-in. plate, heavily reinforced to prevent warping by the heat. The wheels are cast steel with roller-bearing hubs. It is built exceptionally low, with a height of only 24 in.; gage, 36 in.; length, 12 ft.; width, 5 ft. 5½ in.; capacity, about 95 cu.ft. The use of these cars has greatly reduced the boiler-room inconvenience and labor.

Solving the Cinder Problem at Waterside--III

By Charles H. Bromley

SYNOPSIS—This third article in the series describes more of the cinder catchers used at the Waterside station. By enlarging the flues and reducing the velocity of the gases to less than one-half the original velocity, 40 *per cent., of the cinder was removed. A velocity of* 1½ *ft. per sec. is required to precipitate* 90 *per cent. of the solid particles in the gases. Twenty-four boilers are equipped with economizers for the sole purpose of catching cinder. Revolving conical screens and helical baffles are also described.*

Precipitation of Cinder Often Impractical

The next step in catching cinder at Waterside was to greatly enlarge the flues. Fig. 7 shows the enlarged flues; the dotted lines indicate the original flues. The velocity of the gas was reduced to less than one-half the original velocity, and about 40 per cent. of the cinder was removed. During these tests with the enlarged flues it was found that a gas velocity of 1½ ft. per sec. must be maintained in boiler-furnace flues to precipitate approximately 90 per cent. of the solid matter. Such a low velocity is not practical in places where real-estate values are high, as in the section occupied by the Waterside stations, for flues of enormous proportions would be necessary to handle the volume of gas. Flues with numerous kinds of baffles placed normally with the gas flow were next tried, but they removed little cinder and seriously affected the draft.

Economizers Installed as Cinder Catchers

Twenty-four of the boilers were next equipped with economizers, as shown in Fig. 8. These economizers were installed for the sole purpose of catching cinder, and, as the tubes were staggered as usual, it was hoped that much of the cinder would strike the tubes and be thrown into hoppers below. The installation was a failure, as little of the suspended solids was removed and the economizers so seriously interfered with the draft that they were soon discarded.

SEPARATING CINDER FROM GASES BY CENTRIFUGAL FORCE

A number of experiments were made on removing the cinder by means of centrifugal force, by imparting a whirling motion to the gases and throwing the cinder out into the pockets in the flues or stacks. To try out such apparatus an experiment station was erected.

An interesting centrifugal "filter," Fig. 9, was proposed, and experiments were made on a model, but the results did not justify an installation of this apparatus. Notice the enormity of the flue, and that the gases are caused to sweep down at high velocity over filters at *A*, which hold the cinder but allow the gases to pass. Such an apparatus might prove suitable in ordinary plants where the coal consumption is not high.

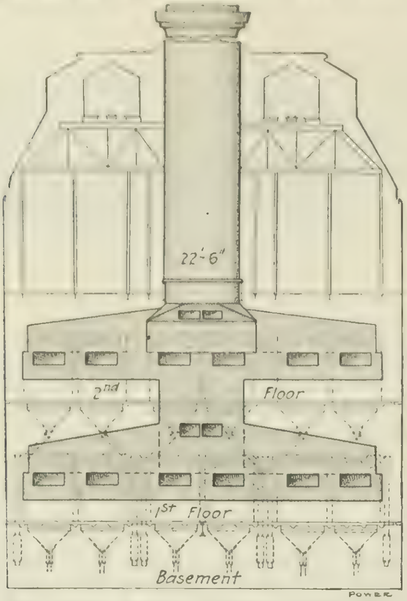


FIG. 7. ENLARGED FLUES; DOTTED LINES SHOW TOPS OF ORIGINAL FLUES

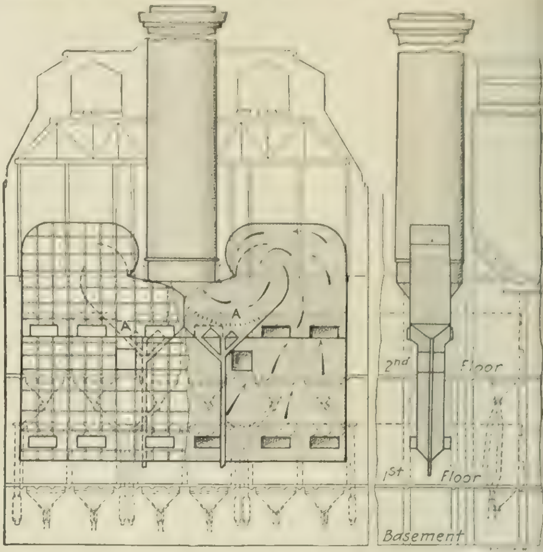


FIG. 9. PROPOSED CENTRIFUGAL FILTER TO THROW CINDER FROM GASES

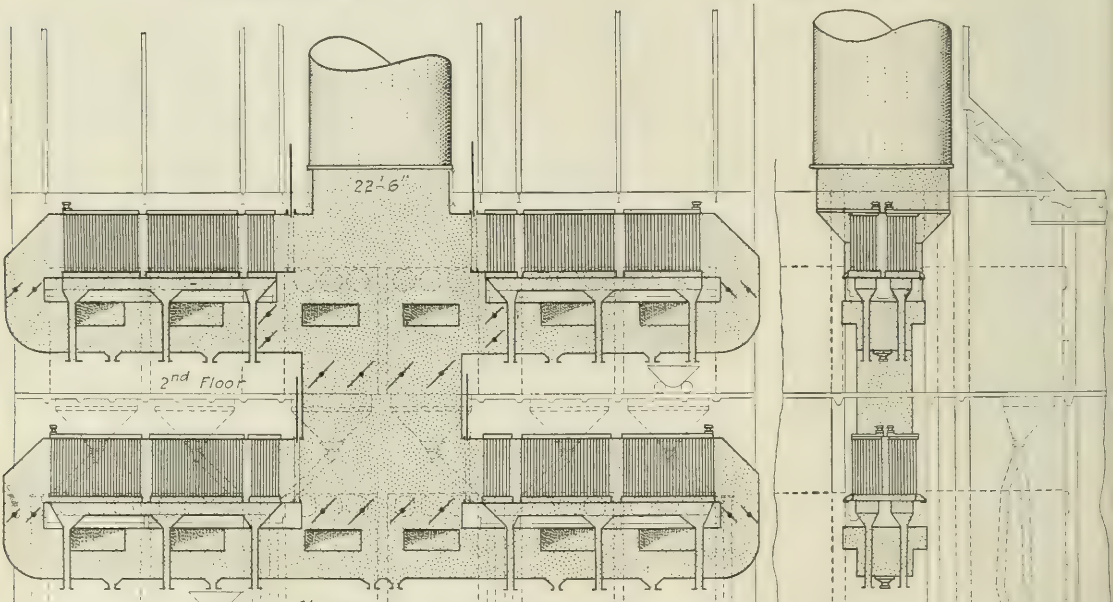


FIG. 8. ECONOMIZERS IN FLUES TO CATCH CINDER; NOTE DAMPER ARRANGEMENT

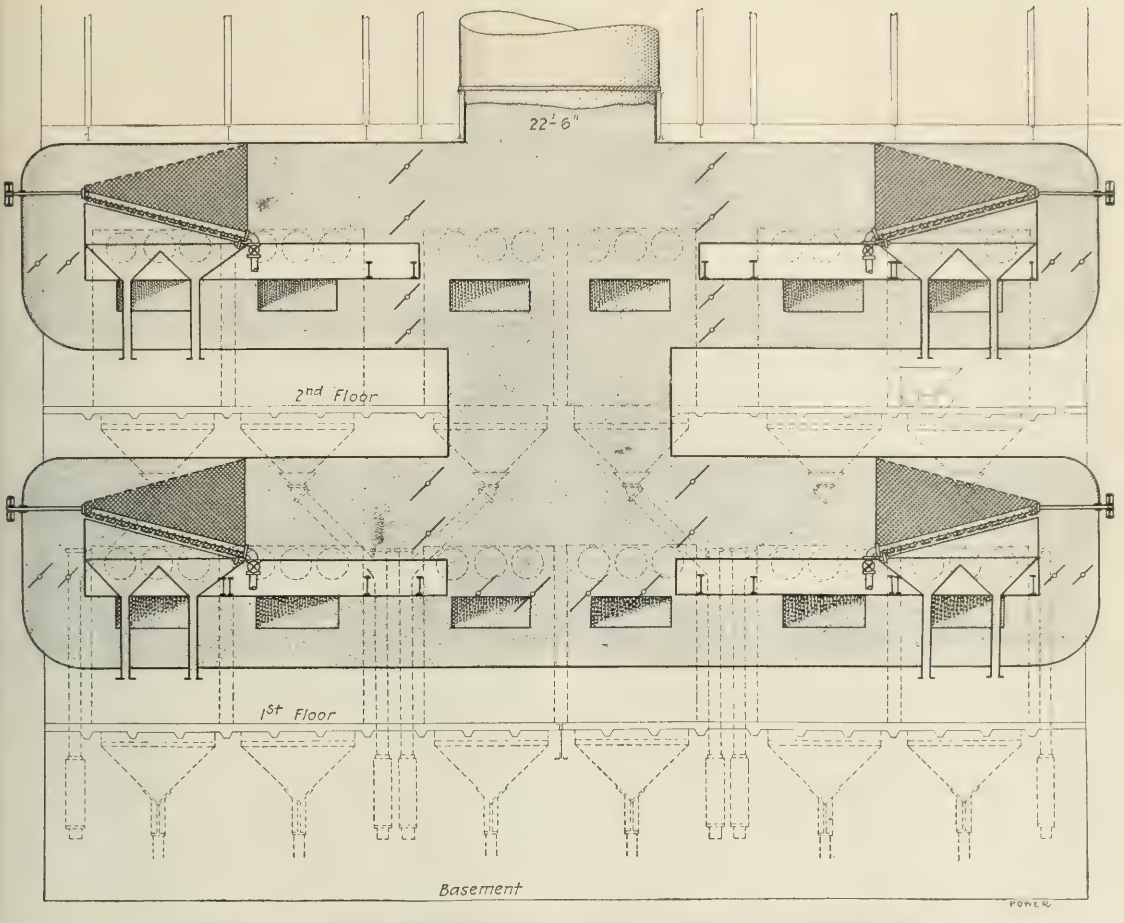


Fig. 10. Revolving Water-Washed Conical Screens; Note Dampers

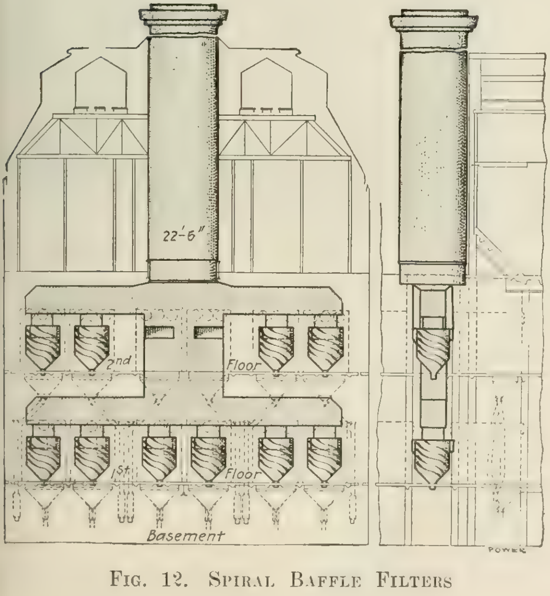


Fig. 12. Spiral Baffle Filters in Boiler Uptakes

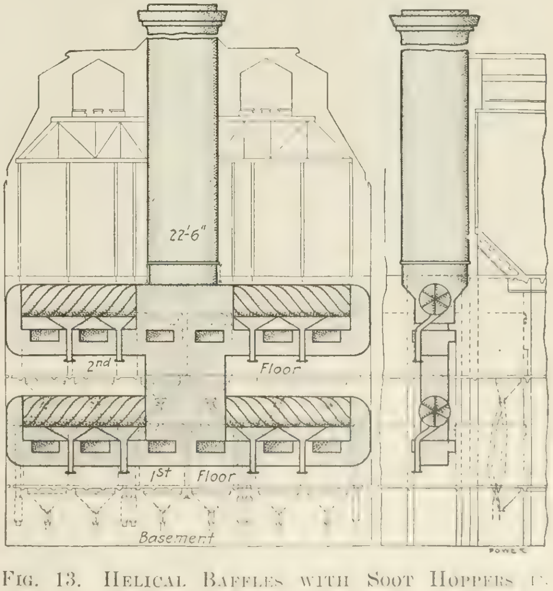


Fig. 13. Helical Baffles with Soot Hoppers i Flues

Revolving Conical Screens in Flues

Revolving conical screens were installed in remodeled flues, as in Fig. 10. The flues were provided with numerous dampers so that the gases could be forced through the conical screens or allowed to be bypassed unobstructed to the stack.

These screens were driven by motors placed outside the flues, each motor driving a screen through a pinion which meshed into gear teeth on the large periphery of the screen cone. Two ways of driving are shown at the left in Fig. 11.

A trough of sheet iron was built under each screen, and had waste pipes leading to the basement. A water pipe was run up in the inside of each screen, as shown, and the side of the pipe next to the screen was perforated to project numerous fine jets of water through the screen and carry the cinder into the troughs from which the waste was carried to the basement.

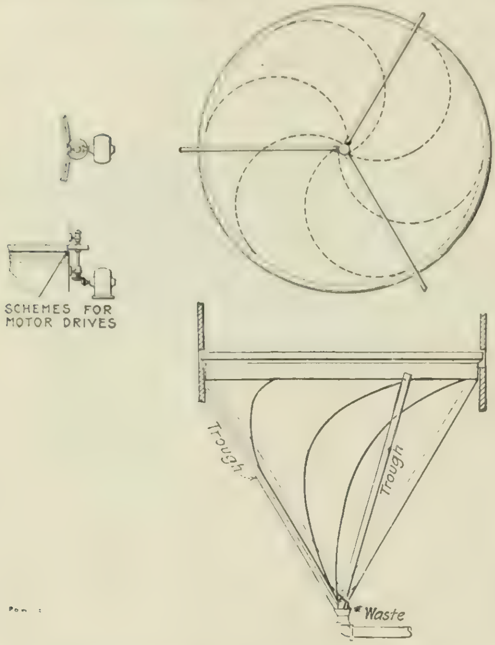


Fig. 11. Diagrams of Vanes and Motor-Drive Schemes for Revolving Conical Screens

Some of the cones were provided on the outside with spiral vanes, Fig. 11, on which the gases impinged, water being run over the vanes and through the screen to take away the cinder. Spiral vanes of corrugated iron were also used to provide more surface for contact with the gases.

Centrifugal Filters and Helical Baffles in Flues

Two interesting methods, planned by an expert in cinder elimination, are shown in Figs. 12 and 13. The former shows centrifugal filters, consisting of spiral baffles in casings placed in the uptake of each boiler; each casing had an outlet at the bottom to take away the cinder.

The same expert designed helical baffle-plates for the flues, the latter being given the same shape and damper arrangement as when the economizers were installed. Fig. 13 shows the arrangement of the baffles, which were provided with hoppers to catch the cinder as it was thrown from the gases.

⁂

Automatically Timed Firing

Many means of firing stationary steam boilers have been instituted in boiler rooms, and the adherent of each is likely to believe that the one he uses is the best for the individual case. There are many firemen, however, who would be skeptical of any means of firing by mechanical timing, believing that such a practice would be disadvantageous both to themselves and to the efficiency of the plant.

An automatic timer has recently been perfected and designed to produce in regular succession and at predetermined intervals, a continuity of impulses for signaling purposes, as by the flashing of lights or ringing of gongs, or both, for indicating the periods at which the coaling and slicing of fires should be done.

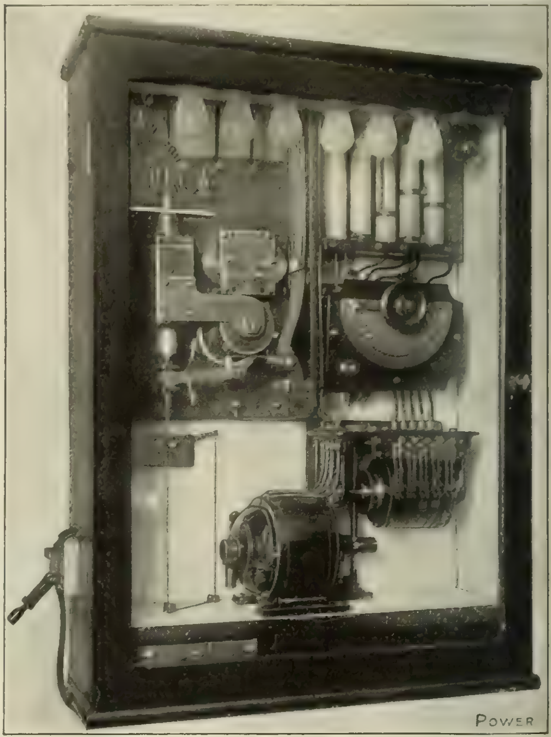


Fig. 1. Essential Parts of the Timer

Referring to Fig. 1, the apparatus consists essentially of four parts. The selecting switch is shown at the center of the right-hand side of the apparatus. It consists of contact points which connect with an internal roving bridge. There is also an external knob handle and indicator as shown.

Below the selecting switch is a frequency drum, operated by a direct-current motor, the speed between the motor and drum being reduced by a train of reduction gears.

On the left-hand side of the apparatus is a sequence drum, the torque of which is maintained by a compound spring motor. The speed is regulated and controlled by an escapement lever operated by a solenoid that is energized by intermittent impulses from the frequency drum.

At the top of the case are indicators, consisting of pilot lamps which are illuminated simultaneously with the field indicators, which latter may consist of lamp signals, gongs, semaphores or other electrically actuated mechanical apparatus arranged singly or in groups as required.

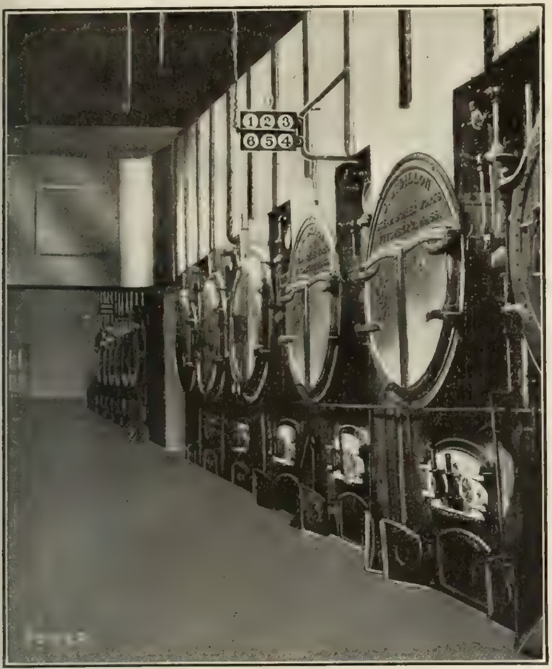


Fig. 2. Boiler-Room Indicator in Position

When used as a signaling device for timing the periods of slicing fires and for firing, the engineer first determines by test the frequency with which the furnace should be fired to maintain the desired steam pressure. He then indicates the time of firing by setting the index of the selecting switch at the point corresponding with such frequency, and the apparatus will then automatically produce the proper signals in the boiler room, Fig. 2, on the field indicators which consist of lamps, etc., as before mentioned. An enlarged view is shown in Fig. 3.

The signaling is accomplished within the mechanism itself by a combination of motor control and distribution of current passing through a series of make-and-break contacts on the periphery of the frequency drum.

As an example of how the device works, suppose it has been the practice for the fireman to throw on a quantity of coal sufficient to last for, say, 20 min. The automatic timer is installed and by tests the engineer finds that 5-min. intervals for stoking is sufficient to maintain the steam pressure when firing, say, four shovels of coal per furnace door. The selecting switch of the timer is set so that the numbered indicator lights will be successively illuminated, and the gong will ring every 5 min. for firing and for slicing the fires. Beginning, say, with No. 1 boiler, the fireman fires so many shovels into No. 1 furnace when that number is illuminated and immediately slices the No. 3 furnace previously coaled. Upon the next signal he coals No. 2 furnace and slices No. 4, then coals No. 3 furnace and slices No. 1 and so on in rotation as the signals are given, alternately firing and slicing the fires at 5-min. intervals.

When additional load is to be put on the generating unit, the engineer times the firing periods to occur more frequently so that by the time the peak load is on, the furnaces are in a condition to maintain the extra volume of steam demanded.

Referring to Fig. 1, a counter will be seen at the left of the motor. This counter registers every firing and by multiplying the number registered during a day's run by the shovels per firing of coal and this by the weight of coal in each shovelful, the total day's coal consumption is determined within a few pounds. It has been found that the amount of coal fired per shovelful day by day does not vary materially. If a tally of the extra coal required for lighting or peak periods is desired a similar calculation starting and ending with the load will give the desired figures. Thus the timer checks the fuel consumption of any particular load.

With this apparatus it is possible to multiply the number of impulses which may be sent out both by the sequence unit and by the frequency unit. This is accomplished by the design of the make-and-break switches which are independent in their action and, therefore, capable of separate and distinct effort at any time. It is possible to transmit the electric impulse from the frequency drum without the intervention of the sequence mechanism, in which case the timing device would consist only of the first and second and possibly the fourth units already described. On the other hand, for any series of operations requiring the transmission of electric energy in periodic succession to two or more points, the third or sequence unit is necessary and the design or type of such unit is dependent upon the number of stations to be successively served.

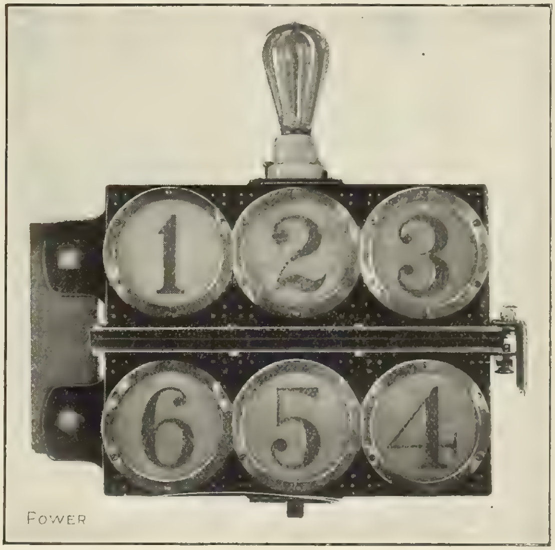


Fig. 3. Boiler-Room Indicator

On the dial plate of the selecting switch there is provided a series of numbered registrations at which points the index may be set to secure the different indications. These vary in periodic frequency from 15 sec. to 10 min.

The range of usefulness of this timing device is not limited to the timing of boiler stoking and elimination of smoke. It may be used for automatically flushing toilets throughout a factory and at variable periods of frequency at the will of the engineer or superintendent. It may also be used for controlling the periodic operation of ventilating apparatus in mines or buildings, for the periodic supply of injection water, for the operation of blast valves in smelting furnaces, continuous foundry work, plating and other processes and for any other operation having to be performed intermittently at regular or variable periods of frequency.

The Automatic Timer is sold by the Merchant Engineers Corporation, 30 Church St., New York City.

* *

Concrete Pipe Conduits

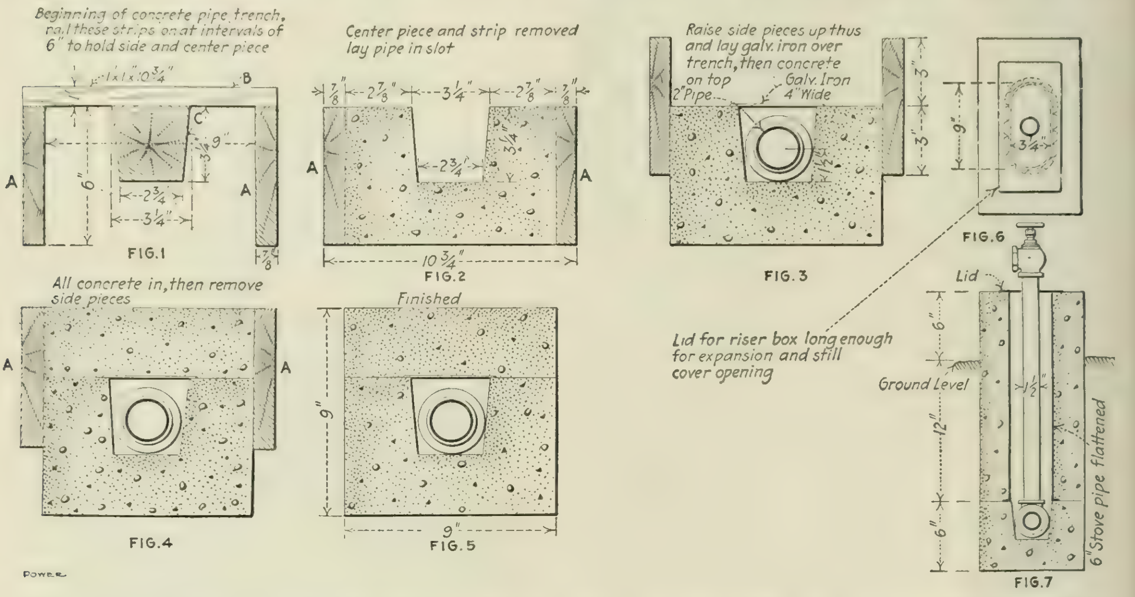
By Fred A. Down

SYNOPSIS—An economical method of constructing efficient and durable conduits of concrete for small steam lines.

*

The trouble experienced in installing and maintaining steam lines underground is well known, especially where cinders have been used for grading. To lay a pipe line in cinders means a continuous digging up and renewing of pipes, for the life of wrought-iron or steel pipe in cinders is short and cinders alone make a poor insulator.

Some kind of covering must be employed to save the pipe and to prevent condensation. After using several kinds of material, including tin-lined wood casing, ordinary tile, split tile, and oak, pine, cypress and other kinds of wood coverings, each has been found to have its faults. I have used concrete conduits for air and oil lines, there being little expansion or contraction, but providing for a steam line is a different proposition. With the knowledge gained in laying approximately 17,000 ft. of air lines in concrete and knowing that it was immune from disintegrating action of the elements and of the cinders, I employed a similar conduit for steam pipes. It is very simple and less expensive than others, and to those who would keep down the cost of maintenance and raise the standard of service, our manner of providing conduits for small sizes of underground steam pipes may be of interest.


Beginning of concrete pipe trench, nail these strips on at intervals of 6' to hold side and center piece
1x1x10¾"
B
C
A
A
6"
9"
3"
2¾
3¼"
⅞
FIG.1
Center piece and strip removed lay pipe in slot
⅞"
2⅞"
3¼"
2⅞"
⅞"
A
A
2¾
¾
10¾"
FIG.2
Raise side pieces up thus and lay galv. iron over trench, then concrete on top
2" Pipe
Galv. Iron 4" Wide
3"
3"
FIG.3
9"
3¼"
FIG.6
All concrete in, then remove side pieces
A
A
FIG.4
Finished
9"
9"
FIG.5
Lid
Lid for riser box long enough for expansion and still cover opening
Ground Level
6"
12"
6"
1½"
6" Stove pipe flattened
FIG.7
POWER

Figs. 1, 2, 3, 4 and 5. Cross-Sections of Conduit. Fig. 6. Lid for Riser Box. Fig. 7. Vertical Section of a Riser Box. Concrete Conduit for 2-In. Steam Line

Our method of providing for a 2-in. steam line would be to first dig a trench the required size and depth, and set in it two ⅞x6-in. fence boards *A*, Fig. 1, placed on edge 9 in. apart. Next, nail a piece *C*, used as a core for forming the slot in the center, to the strips *B*, 1x1x10¾ in. spaced 6 ft. apart, and tack them to the side boards. The ditch is then filled with concrete in sections, each about 12 ft. long, made of 10 parts of small stone or gravel, five parts sand and two parts cement. Mix the concrete to a slush and fill the form level with the top. Do not trowel the top, but use a broom to roughen the top surface, as the top will adhere better than if slicked with a trowel.

When the concrete is set, and it will generally harden enough in 12 hr., remove the strips *B* and lift out the center core, leaving the concrete as shown in Fig. 2.

Now lay the pipe, as shown in Fig. 3, and cover the slot with a strip of thin galvanized or stove-pipe iron about 4 in. wide. Raise the side boards up 3 in., tamp dirt around the outside to hold the boards in place and fill with concrete to the top of the side boards, as in Fig. 4. When the concrete has set dry, remove the side boards, leaving the finished conduit of section like Fig. 5. If the ground is likely to hold water after a rain, it is well as an extra precaution to coat the sides and top of the conduit with hot coal tar, or with a heavy paint.

Care should be used where the risers come above the ground. For such places use a piece of 7-in. stove pipe of the right length, split and flanged over at the lower end, and flatten the sides so as to leave space for the steam line to expand. After placing the stove pipe over the riser, set a box 9x15 in. around the stove pipe, both extended about 6 in. above the ground line, and fill with concrete, as in plan, Fig. 6, and vertical section, Fig. 7 When the concrete has set, remove the outside form, pack the dirt firmly around the riser box and provide a sliding lid of sheet iron, as shown, to exclude dirt and hinder the circulation of air.

If a leak appears, remove a section of the top with a wedge, draw out the pipe, repair the leak and replace the top with new concrete. A length of 25 ft. of pipe can be drawn out and replaced with no trouble. This cannot be done with wood, log, tile, wooden box, or most other kinds of conduit on account of the inside supports. I have installed many hundred feet of this kind of conduit and can find no trace of cracks at any of the places that were uncovered to examine the concrete.

* *

Operating Troubles When Burning Oil

By J. J. McIntosh

SYNOPSIS—Troubles from water and carbon, leakage, piping that is too small and pumps of insufficient capacity.

*

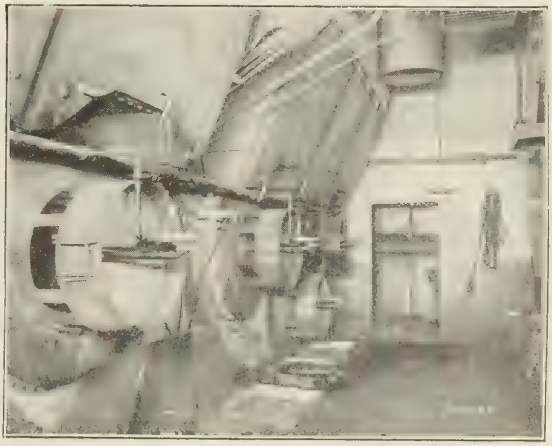
Although oil is an ideal fuel for steam-generating purposes, there are many times when the operating force experience considerable trouble in the burning of this fuel. These troubles are almost invariably due to an improper installation. It is to be regretted that the designing and installing of a plant for the burning of oil is often entrusted to persons who have had little practical experience with oil fuel, as the efficiency and reliability of the plant are primarily dependent upon the character of the installation.

Probably the most frequent trouble encountered by the operating engineer is backdraft and sputtering of the burners. This trouble is commonly called "bucking." With the fire going out at short intervals, accompanied at each ignition with an explosion of the furnace gases (causing the backdraft), with large clouds of smoke issuing from the stack and steam pressure going down, the engineer's patience is indeed sorely tried. One of the most frequent causes bringing this condition about is water.

In many cases no precaution is taken to prevent water from entering the oil well and no provision made to clear it of water. Of course, engineers allowing such a condition of affairs to exist must expect trouble. The suction pipe should never be placed closer than 4 in. to the bottom of the storage tanks and ample facilities must be provided to clear the tanks of water. The common steam siphon will be found a convenient and cheap appliance for this purpose.

Sometimes a plant is fitted with a foot valve on the suction. On account of the nature of fuel oil this appliance ought to be omitted, and its cost applied to good strainers. A plugged foot valve increases the vacuum carried on the suction line, which may cause the oil to give off its lighter fractions. This gas in issuing from the burners causes bucking.

In many oil-burning plants the suction lines are too small. This is a mistake frequently made by those who have had little practical experience with fuel oil. They assume that the same size suction will do for oil as for water for the same quantity pumped. On account of the viscosity of fuel oils, their flow is sluggish unless highly heated. As fuel oils give off their lighter fractions when their temperature is increased above a certain point, without a corresponding increase in pressure, it is obviously impossible to decrease their viscosity on the suction side of the pumps to such an extent that their flow will be the same as water. If trouble is to be avoided, the suction pipe must be from one to two sizes larger than that necessary for the pumping of water.



Marine Installation of Koerting Mechanical Burners

The same trouble is experienced in installations having an insufficient pump capacity. One authority on fuel oil states that the speed of pumps used to pump oil to the burner line should never exceed 20 strokes per minute.

It is obvious that if the oil becomes hot enough to give off its lighter fractions, that trouble is sure to occur. Every fuel-oil installation should have some provision on both the suction and discharge sides of the pumps whereby the temperature of the oil can be ascertained at a glance. The operating force must pay close attention to this phase of the work at all times.

Oil-Fired Boilers at Southern California Edison Co.'s Plant at Long Beach

Leaky pumps, suction lines, valves, etc., will cause bucking. Air issuing from the burners will put out the fire. Air chambers will materially reduce this trouble, but in any case all piping, valves, pumps and other appliances ought to be absolutely tight.

Pump pulsation may cause bucking of the fire. An air chamber or a gas separator will remedy this trouble by smoothing out the pulsations of the pump.

Another source of trouble in oil-burning plants is carbon. The formation of carbon in the furnace indicates incomplete combustion and may be brought about by a variety of conditions. It is generally caused by a partly plugged burner, wet steam, water in the oil, too wide or worn burner tips or by an improperly designed furnace.

The melting out of furnace firebrick can generally be traced to localized heat or blowpipe action.

In fitting up a plant for oil burning it is important to provide ample means for delivering clean hot oil to the burners and to select a burner that will maintain a clear flame in a cold furnace.

In designing a furnace practice has shown that practically all air must pass through the flame; that the flame must not be allowed to impinge directly on either boiler sheets, tubes or brickwork; that the flame produces better results when worked near hot brick and distributed over as large an area as possible to prevent localization of heat; that every precaution must be taken to guard against excess air, and that the efficiency and reliability of an oil-burning installation is primarily dependent upon the character of the installation.

Emptying Ammonia System

By Thomas G. Thurston

Pumping out the ammonia from the different parts of a modern refrigerating system should be a comparatively simple matter, but I have found from experience that a large number of men who called themselves refrigerating engineers were incapable of and totally unfamiliar with pumping out a section of the system for alterations or repairs.

Most compressors are now provided with pump-out connections so that any section of the system can be pumped out and the ammonia stored in another part of the system. Generally a compressor is provided with bypasses or cross-connections, and a separate pump-out line from the suction side of the compressor to the condenser, liquid receiver and sometimes to the liquid line. In a double-pipe or atmospheric condenser the pump-out line is connected to each individual stand, so that each stand can be pumped out separately.

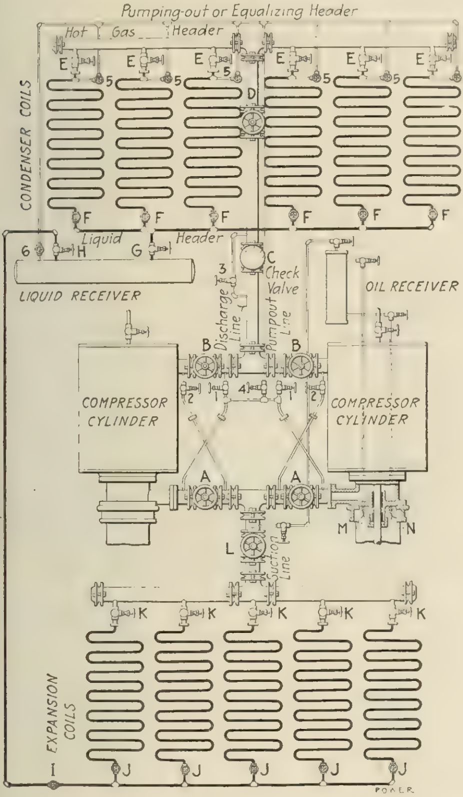


Fig. 1. An Ammonia Compression System with Pump-out Connections

The beginner and a large number of the more or less experienced men look at the bypasses as some sort of a Chinese puzzle. Nothing could be more absurd, however, as by tracing the piping it is simple enough to determine the purpose for which they were intended—to reverse the suction and discharge connections of the machine so that it will pump from the discharge line and discharge into the suction line. To run the machine this way, the main suction and discharge stop valves are closed when the machine is shut down and the bypass valves are opened instead.

Fig. 1 shows the pump-out connections for a vertical single-acting twin-cylinder compressor. Suppose that it is desired to pump out the suction line. This may be done by closing the valve *L* near the suction header on the expansion coils if there is one, or if there is not by closing all the suction valves *K* on the expansion coils. The machine is kept running as in normal operation until the suction-pressure gage indicates a slight vacuum. This operation may have to be repeated several times as a suction line is generally covered and any liquid ammonia which may be present in the line evaporates slowly. When the suction gage indicates no rise in pressure after the machine is shut down, it is safe to assume that the line is pumped out, although precautions should be taken even then, if joints are opened, against an escape of vapor.

The suction-gas header at the expansion coils is pumped out by closing the suction valves *K* on the expansion coils and proceeding as before. In case one or more of these valves leak, close all the expansion valves *J* on the coils and pump the coils down to zero or a slight vacuum before closing the suction valves *K*.

To pump out the expansion coils, close valve *I* in the liquid line at the expansion coils, if one is provided; otherwise close the expansion valves and go ahead as before. A better and safer method is to close the valve *H* in the liquid line at the receiver, pump the coils down to zero a couple of times, then close valve *I* and the expansion valves and finish the pumping with these closed. This will eliminate trouble from leaky valves. In case a single coil is to be pumped out it is better to proceed the same way for the first pumping out. Then close valve *I*, the expansion valve on the coil to be pumped out and the suction valves *K* on all the other coils. Pump the coil down, close the suction valve *K*, open the suction valves on the other coils, open the valves *I* and *H* in the liquid line and the machine is ready to resume normal operation.

The liquid header at the expansion coils is pumped out in the same way. For the first pumping, valve *H* is closed. Valve *I* at the header is then closed and the pumping finished. The expansion valves *J* should be closed immediately after the machine is shut down, to keep the gas from backing into the header from the expansion coils and the suction line. If valve *I* is not provided the liquid line must be pumped out with the header.

Suppose it is desired to repair some part of the machine or pack a stuffing-box; any good engineer who wishes to keep down his ammonia bill will pump out the machine to do this, but I have seen a number of engineers just shut the suction and discharge stop valves, open the indicator cock or purge valve and let the ammonia blow to the four winds. To pump out the machine, close the main suction and discharge stop valves *A* and *B*, when the machine is stopped, and the valve *D* in the discharge line to the condenser. Open valves 1 and 2 on the bypasses and the bypass valve 3 on the bypass to the check valve C in the discharge line. By tracing the connections it will be seen that the machine will now pump from the discharge line and discharge into the suction line. Run the machine slowly and when the head pressure gage indicates a few inches of vacuum shut the machine down and just before it stops close valves 2 on the bypasses. This prevents vapor from the suction line backing up into the machine when it stops. Now open the discharge stop valves *B* slightly to let the vapor between these valves and the discharge valves in the machine escape into the discharge line. It is for this reason that a vacuum is pumped on the discharge line.

Close the stop valves *B* again and valves 1 on the bypasses, also valve 3 on the check-valve bypass; then open the purge valve and let the remaining vapor if any escape to the atmosphere.

In pumping out a machine, care should be taken to close valves *M* and *N* on each side of the oil lantern, especially if the packing is bad, as the vapor will leak back through the gas-relief line of the oil lantern and through the last half of the packing into the machine.

When ready to start, turn the machine over a few revolutions with the purge valves open to expel the air from the machine, then close the purge valves and start up in the regular manner.

Pumping out the discharge line is done in the same way except that the operation may have to be repeated a couple of times to get all of the vapor out, as there is always more or less ammonia in the oil trap, which takes time to evaporate.

To pump out the gas header on the condenser close the stop valves *E* on the individual stands and leave valve *D* open. Then proceed as before. Trouble is often occasioned by one or more of these valves leaking. In this case close the liquid valves *F* between the coils and the liquid header on the coils or stands having the leaky gas valves. Leave the leaky gas valves open and pump out the coils with the header. In doing this I have found it good practice to drain the water from the coils where a double-pipe condenser is used, as it is liable to freeze and burst the pipe or return bends unless a good circulation is kept up.

To pump out the condenser, close the valve *G* in the liquid header at the receiver and use the bypasses the same as before. Keep the water circulating rapidly or better still drain the coils in case a double-pipe or submerged condenser is used. Otherwise some of the coils are likely to be found burst after pumping out. I can remember one case where a condenser was ruined by the engineer failing to take this precaution.

An individual stand is most readily pumped out by the pump-out line and most of it can be done while the machine is in normal operation by closing the liquid valve *F* between the coil and liquid header and valve *E* between the coil and gas header, thus cutting out the coil. Valve 5 in the pump-out line is opened and valve 4 at the machine. The coil will then pump down to suction pressure with the machine in normal operation. After this the operation can be finished by closing the main suction stop valves *A* on the machine and pumping on the coil alone. A gage should be provided on the pump-out line to avoid pumping a high vacuum on the line and drawing air into the system.

A coil can also be pumped out by using the bypasses. The liquid valve *F* on the coil to be pumped out and the gas valves *E* on all the coils but that one are closed. This is more like work, however, and keeps the machine out of service longer.

I can remember one case where with no pump-out line and no bypasses a condenser coil was pumped out by closing the liquid valves *F* on all the coils but the one to be pumped out and closing the gas valve on this coil. The coil was pumped out through the expansion coils, the liquid line and liquid receiver.

The liquid receiver can be pumped out through the pump-out line or the expansion coils and the liquid line, or through both in succession, which is the best and quickest way. Close valve *G* in the liquid header between the condenser and the receiver, pump down to zero a couple of times, close valve *H* in the liquid line and stop valves *A* at the machine and finish the pumping with the pump-out line.

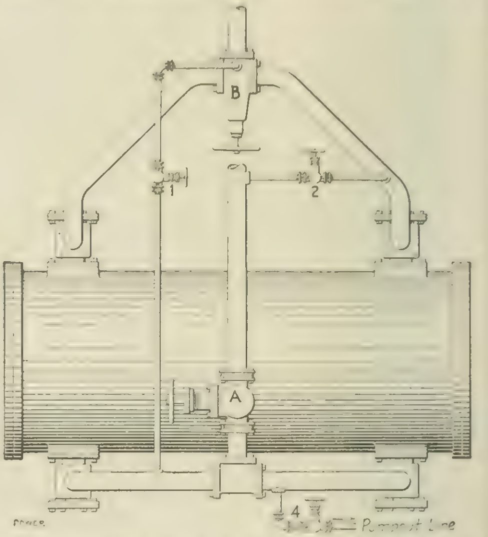


Fig. 2. Pump-out Connections on a Double-Acting Compressor

Pumping out the liquid line is about the hardest problem because the line is generally covered and the liquid evaporates slowly. If the pump-out line is connected to it at the receiver end it can be pumped from both ends at once. The liquid will drain to one end or the other and pump out more readily. If the pump-out line is not connected, time and trouble will be saved by pumping out both the receiver and liquid line in the same way as just described for the receiver.

All the instructions apply where one machine is in operation. Where there are several the pump-out connections are generally connected to a common line both from the machines and the condensers, so that any machine can be used for pumping out. The suction and discharge headers are also cross-connected in a large number of cases. This makes pumping out possible in a number of cases where otherwise it would be necessary to let the ammonia blow to waste.

As an illustration, last summer a suction valve blew out on a horizontal machine. After the suction and discharge stop valves had been closed it was found that the discharge valves leaked enough to make it unpleasant around the machine. We closed the stop valve in the discharge line at the condenser header and intended to let the vapor blow away when I happened to think that one of the discharge lines of the other machines was cross-connected to it. By using the cross-connection and bypasses on the other machine it was possible to pump down the line, saving the ammonia and making it more pleasant for the men to work at the machine.

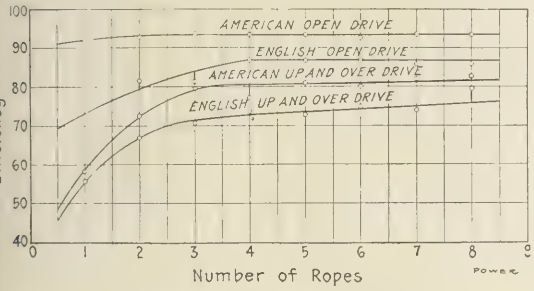
In another case we broke one of the discharge valves on one of two machines working on the same system. It did not interfere with the regular operation of the machine but made it impossible to shut the valve off and a slow job to pump the machine out. We finally hit upon the idea of pumping it out with the other machine. We left the suction-stop valve open on the machine with the broken discharge valve, opened the bypass from the discharge side of the machine to the suction line and the bypass on the check valve, first closing the valve in the discharge line at the condenser, letting the vapor from the discharge line escape through the bypasses into the suction line which was pumped down to zero by the other machine.

Fig. 2 is a detail of the bypass on a double-acting compressor which requires only half the number of connections that are required by the machine shown in Fig. 1. By comparing the two illustrations, it will be seen that the valves which are marked with the numbers 1 and 2 in Fig. 2 serve the same purposes as the valves of the same numbers in Fig. 1.

* *

Efficiency of Rope Driving

In an interesting paper read before the American Society of Mechanical Engineers, E. H. Ahara gave the results of a series of 700 tests on the transmission of power by rope drives under various conditions. The tests were all made in the open air at the plant of the Dodge Manufacturing Co., Mishawaka, Ind., on both American and English systems with open and up-and-over drives. The results include the friction of the receiving shaft and bearings, as it was thought this would more nearly approximate working conditions. The bearings were of the ring-oiling babbitted type and the ropes were all 1-in. manila of the best quality, carefully treated with a rope dressing to prevent the entrance of moisture and to keep the surface in as nearly uniform condition as possible.



EFFICIENCY OF ROPE DRIVES

The general method of conducting the tests embraced the use of a 250-hp. Westinghouse direct-current motor, driving through an auxiliary rope drive to a jackshaft on which was mounted a 60-in. test driver; the driven shaft was fitted in bearings on a movable tower, and on the driven shaft was mounted the receiving sheave, of the same diameter as the driving sheave, and also a prony-brake wheel. The tests were made on rope drives containing from one to eight ropes, each under speeds of rope travel of 2500, 3500, 4500 and 5500 ft. per min. The center distances were varied in steps of 25 ft. from 25 to 150 ft., and at the same centers tests were made with varying loads.

On the American open drive it was found that the efficiency was greatest at the lowest speed. At a rope speed of 2500 ft. per min. the efficiency was approximately 96 per cent., and at 5500 ft. per min. about 90 per cent. The results of the efficiency tests relative to varying centers were practically uniform, and those on efficiency as to the number of ropes showed a lower efficiency on the lower number of ropes. With one rope the efficiency was about 88 per cent. and with three ropes it increased to practically 93 per cent.; from three up to eight ropes it remained constant. The lower efficiency up to three ropes was probably because the eight-grooved wheel, made for testing eight ropes, was used for all the lesser number of ropes, and this, together with the weight of the prony brake, increased the proportional friction on the smaller loads, so that it would be a larger percentage of the total load in the drive of few ropes. Limiting the losses to those in the rope alone, it was believed that the efficiency of a single rope would be as great, if not greater, than any multiple thereof. At 100, 75 and 50 per cent. loads the efficiency was practically uniform, but at one-quarter load it dropped approximately 7 per cent.

Tests to ascertain what tension in the slack side of the rope would give the highest efficiency showed that 180 lb. was best. Up to 180 lb. the efficiency increased, and from there up to 360 lb. remained constant.

Efficiency tests comparing exact and differential drives gave results considerably in favor of the former.

The up-and-over American drive, so called because of its course upward from a driver over idler wheels, then horizontally for a distance, and down over idler wheels to the driven wheel, was tested on approximately 100-ft. centers. The results of efficiency versus number of ropes, shown in the illustration, will serve as a basis of comparison where but two additional right-angle turns are introduced, requiring four additional idlers.

The results obtained in the tests of the English open drive showed a falling off in efficiency with increase in speed, the drop running from 90 per cent. at 2500 ft. per min. to 84.5 per cent. at 5500 ft. per min. The efficiency of the English drive also remained practically constant irrespective of center distances. With reference to the number of ropes, it increased, as did the American system, for the first few ropes, and then remained almost constant.

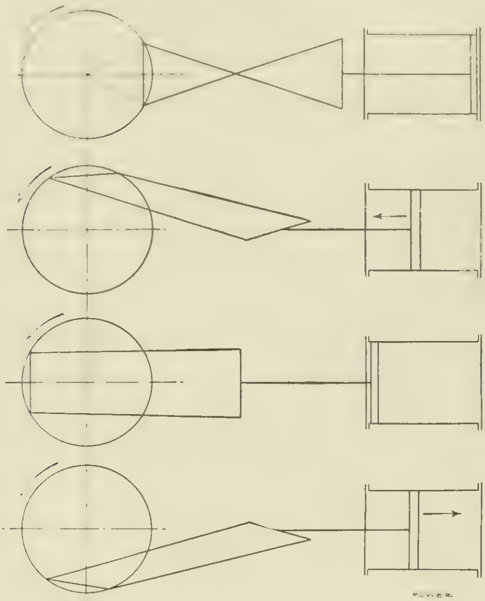
In the up-and-over English drive, tests at the four speeds previously given showed that the efficiency increased rapidly with the first three ropes and then gradually up to eight ropes, although the maximum efficiency was not as high as that attained with the open drive.

The illustration gives a representative comparison of the efficiencies of the four general plans of rope driving, at a center distance of 100 ft. and a rope speed of 1500 ft. per min. These tests were made at three-quarter load, which would be 165 hp.

* * *

The Williams Connecting-Rod System

The principle of the double connecting-rod devised by T. Williams, manager of the Harvey Engineering Co., of Glasgow, referred to in the editorial on page 202, is shown in the diagrams reproduced herewith from *The Engineer*.



THE WILLIAMS DUPLEX CONNECTING-ROD

The stroke of the piston is less than the diameter of the crankpin circle, permitting, for the same stroke, an increased crank throw and the choice between a slightly shorter length of bed or a slightly longer connecting-rod. The claims advanced for its effect upon steam economy seem to us to be preposterous.

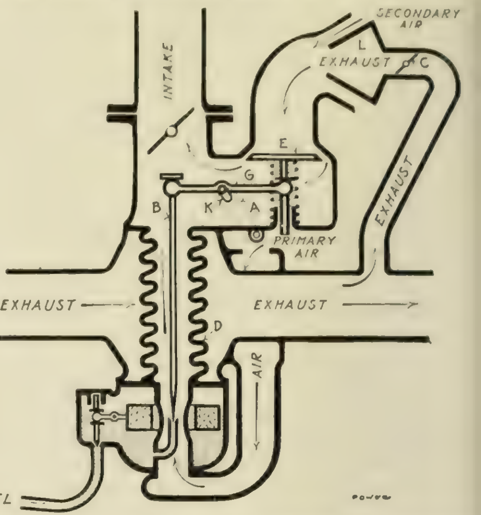
* * *

Harroun Kerosene Carburetor

The illustration represents a sectional view of the Harroun kerosene carburetor. Part of the exhaust is forced through the space around the venturi which heats this corrugated surface to a cherry red. This passage is of spiral form and as the dense atomized fuel is drawn through by the suction of the motor the heavier parts are thrown to the outside against the heated surface by the centrifugal force and the more volatile portion remains in the center.

The fuel, as it is sprayed from the nozzle and comes i contact with the hot surface, is turned into a vapor. Thi vapor is partially mixed with air which comes throug from the bottom of the venturi and is further diluted wit cold air passing through the secondary air valve.

The fuel inlet in the nozzle is automatically opened an closed by the action of the secondary air valve, an there is but one adjustment of the carburetor, this is a



SECTION THROUGH HARROUN KEROSENE CARBURETOR

the lever *A*, which raises and lowers the fulcrum of th rocker arm and in turn raises and lowers the needle *B* as it is actuated by the air valve *E*.

A special feature of this carburetor is the taking of small portion of the exhaust gas back into the charg through the air-valve opening. This prevents preignitio and eliminates the disagreeable pound more prevalen with kerosene than with gasoline. The amount of exhaust gas used is determined by the butterfly valve *C*.

* * *

Petroleum Production in 1913—The output of petroleun in 1913 exceeded 240,000,000 bbl., according to estimates o David T. Day, of the United States Geological Survey. Th production in 1912, which made the record up to that time was 222,113,218 bbl.

The following is an estimate of the production in 191 compared with the statistics for 1912:

State	1913	1912
California	98,000,000	86,450,76
Oklahoma	62,500,000	51,427,07
Illinois	22,000,000	28,601,30
Texas	14,000,000	11,735,05
Louisiana	12,000,000	9,263,43
West Virginia	11,000,000	12,128,96
Ohio	8,000,000	8,969,00
Pennsylvania	7,000,000	7,837,94
Wyoming	3,000,000	1,572,30
Kansas	2,000,000	1,592,79
Indiana	900,000	970,00
New York	800,000	874,12
Kentucky	500,000	484,36
Colorado	200,000	206,05
Other states	100,000	....
Total	242,000,000	222,113,21

* * *

Pennsylvania's Anthracite Production in 1913—Final figures for 1913 show that the total shipments of anthracit coal from Pennsylvania last year were 69,069,628 tons. Thi is 5,459,050 more than in 1912, when the output was curtailed during the suspension of work pending the signing o a new scale of wages. The tonnage is 884,669 tons less tha in 1911, which was the record year for high production.

Editorials

Transportation Problems of the Power Station

Transportation is the backbone and life of manufacturing and mercantile interests, for without it business paralysis would inevitably result.

The transportation problem begins with the erection of the power station and its adjuncts, regardless of whether it is hydro-electric development or steam generation, although in subsequent operation the steam-generating station is at the mercy of transportation companies to a greater extent than is the hydro-electric plant, where the only transportation problems of serious importance which develop after the plant is once in operation, are those connected with extensions and repairs.

With the steam power plant, however, the situation is different, for there, the unceasing problem of fuel supply, and the possible interruptions to service connected therewith, is always present. The character of the service and, above all, whether it is divided between two or more companies and is competitive and wholesome are factors to consider.

It is of vital importance, in the selection of the site for a power station, to have a liberal regard for all that pertains to transportation facilities at the outset and also in subsequent operation.

Eight Dollars a Week

When is an engineer not an engineer? No, this is not a conundrum, but a plain question that needs a specific answer, judging from the indiscriminate use of the word. We answer that an engineer is not an engineer when he is a fireman, or an oiler, or an engine starter; not until he is capable of operating or of directing the operation of a steam power plant.

How foolish, then, is the following advertisement that appeared recently in a New York daily newspaper:

> ENGINEER wanted, elderly man, third-class license. attend boiler only; wages, $8. ....

An engineer knows how the various appliances in a steam plant operate; what to do in case they do not work efficiently, how to handle men, and how to plan for improvements and new installations. Such men do not work for eight dollars a week.

Evidently a man is wanted to throw coal into the furnace of a boiler, and he will have nothing to do with an engine or a real engineer's job. A man with a fireman's license could fill the job as well as a "third-class engineer," if one would work for the wage offered, which is doubtful.

An elderly man is preferred, doubtless because it is assumed that a man of advanced age, holding but a third-class license, has been a failure in the engineering field and will be glad to take the job at any wages. Such a man will not be ambitious to advance and will stay contented. Probably the advertiser is tired of breaking in young men, who leave when they have learned enough to earn more money elsewhere.

On the whole, the engineers employed in stationary steam plants are intelligent and capable men. They are interested in the efficient operation of their plants, and those who are climbing are working hard to fit themselves for places of higher responsibility.

Such men should not be confused with "engineers" who care nothing for advancement, who are failures in their work, and who can be hired for a wage of eight dollars a week.

Inspecting Smoke

> Because of opposition from the National Association of Stationary Engineers to the plan of having the Pittsburgh smoke inspector either a metallurgical or mechanical engineer, the city council has been forced to postpone action on an ordinance providing for the position and fixing the salary. The stationary engineers think such a provision would be unfair to men who have learned all about boilers and furnaces by experience and study, but who may not have a college degree. The engineers say they ask for no preference to be shown, but are opposed to having college graduates given preference over practical men who may be more competent.

Thus runs a news item from Pittsburgh.

We have no wish to encourage the often exaggerated antipathy of the practical man for the one with a theoretical training only. Quite the reverse, one of our ambitions is to show each the value of the other and urge their coöperation. Nevertheless, we must remark the evident justice of the stationary engineers' contention in this instance, for there is about as much reason why a smoke inspector should have a college education as that a baseball player should have had a course at a conservatory of music.

As we see the qualifications necessary in a satisfactory smoke inspector, next to good eyesight, the essential is a knowledge of the principles of combustion born of practical experience sufficient to know how to obtain smokeless burning of various fuels under various conditions. It matters not whether this knowledge was gained in or out of college.

A college education is not to be disparaged, for it can be a great advantage to anyone. The main benefit derived from it, however, is not what is learned of specific subjects, for this is soon forgotten unless the study is continued after graduation, but learning how to learn; that is, it is the training of the mind to habits of observation and deduction therefrom. Even then if the habit of thought is not related to a habit of action it is of no profit. It is the ability to apply his trained mind to useful purposes that determines the successful man. This is just as true of the man who never saw a college, but was gifted with a mind capable of training and had the determination to train it, school or no school. Such men are successes not because they had no college education, but in spite of that fact. It is the greater credit to them.

So, if we were selecting Pittsburgh's smoke inspector, we would give him no examinations in Latin, higher mathematics or any of the "ologies." If he could pass an eye test that showed he was not seriously myopic and could explain how to burn coal completely and then prove it by actually doing it, we should accept him. And if we could get two or more such men that were equally good in these respects, we should give the preference to the man who evidently possessed the most tact so that, instead of antagonizing the offenders against the smoke laws, he would educate them to the economic advantages to themselves of complying with them.

⁂

A Magic Rod

What is the use of fussing with multiple cylinders, high pressure, superheat, etc., to increase the efficiency of an engine a small amount when by putting on a double connecting-rod you can save fifteen per cent.?

Some months since, the *London Times* described a new connection between the crosshead and the crankpin disk devised by the manager of the Harvey Engineering Co., of Glasgow. It was not surprising to see a nontechnical newspaper accept without question the statement that the use of this rod on a twenty-five-horsepower engine made a saving of seventeen per cent. in steam, and that a two hundred-horsepower cross-compound condensing engine so equipped ran on ten and a half pounds of saturated steam per indicated horsepower-hour, at one hundred and twenty pounds pressure (an efficiency of nearly eighty-three per cent.), but it was rather startling to see our dignified and conservative professional English contemporary, *The Engineer,* devote over two pages to a serious consideration of it. That paper believes "that the decreased steam consumption is, in good part, due to the circumstance that the power developed in the cylinder is transmitted more evenly to the crankshaft than is usual."

The energy developed will be the product of the pressure and the piston displacement, and no modification of the connecting mechanism can, for the abstract case at least, make any difference in the ratio of that energy to the steam required to produce it. It is conceivable that by a better distribution of the crank effort the mechanical efficiency might be improved, but inasmuch as the total internal friction of a simple engine should not exceed ten per cent., it is not easy to see how a saving of seventeen per cent. is to be accounted for along these lines. The arrangement is described on page 200.

⁂

State or Federal Control?

The *New York Sun* predicts a row between Gifford Pinchot and the President over the question whether the state or the federal government shall control the water powers, and whether either shall collect a rent or tax for their use.

The interests which are seeking to acquire and control the water powers are strong for state rights, which would seem to be a pretty good cue for those who want to save them for the people to put them under the control of the stronger and less susceptible federal power.

So far as the tax is concerned, with a proper system of rate control, it becomes one of the expenses of the business, is charged in when the rate is established and passed on to the consumer. It is only when the power is sold at what the market will bear instead of at a price which will pay a predetermined profit on the investment involved, that the public gets any net good out of a franchise tax, and it is to be hoped that the people will relinquish their hold upon these remaining sources of power only upon such terms as will insure their prompt development and the availability to the public of energy at rates which will pay a fair profit upon the money actually invested in its production. In which case, what is the difference who makes and enforces the terms so long as they are made and enforced? And which is the more likely to make and enforce them in the interest of the people, a corporation-owned state legislature or a national body whose personnel is known to and whose every act is scrutinized by an aroused people?

⁂

Another Engineer Hero

Conspicuously different from some other of the more recent marine disasters was the sinking of the "Monroe." Usually, some shameful acts of cowardice are reported, but not a single account of such has come from the "Monroe" survivors. Mingled with the feeling of horror that always comes with the hearing of such a terrible tale is one of pride and gratitude that the behavior of an American crew in the face of expected death was so exemplary throughout, from the highest officer to the humblest colored steward.

Among the outstanding displays of bravery and heroism, next to that of Wireless Operator Kuehn, who perished because he removed his own life belt to give to a woman who had none, was that of Engineer Oscar Perkins, who at the risk of his life went down and started a reserve dynamo when the main one was put out of commission and got the lights going again. Without question, this act did much to prevent a greater loss of life and the glory belongs to an engineer.

⁂

Coal Exhaustion

A reader, evidently thinking we are alarmists on the coal-exhaustion question, sends us a very reassuring clipping from a daily paper. It reads:

> The International Geographical Congress has just issued a pamphlet giving results of a study of the subject in 64 countries. The conclusion is that there are more than seven trillion tons yet unmined, while the present consumption is about one billion tons a year. It would seem, therefore, that the world still has coal enough to last 7000 years.

What the International *Geological* Congress monogram on "The Coal Resources of the World" really did say was:

> The total reserves of the world, compiled from all the reports received, amount to 7,397,533 million tons. . . . The world's production of coal for the year 1910 was about 1145 million tons, so that, though much must be allowed for loss in mining and for areas that for various reasons cannot be economically mined, there still remain many hundreds of years before exhaustion of the supply may be looked for. Taking up the individual countries, however, it is found that in more than one case the end is in sight.

Further the rate of consumption is constantly increasing, so that it is not correct to divide our reserve supply by our present annual consumption and call the quotient the number of years that coal will last. We should like to convince ourselves that the "we-should-worry?" attitude toward the exhaustion of the fuel resources is warranted, but we cannot. Just because it will not come in this generation is no excuse for indifference toward the inevitable that must be faced by posterity.

Correspondence

Running Compound Corliss Engine on Light Load

I have handled cross-compound condensing engines successfully by following these rules: Never attempt to start the engine until the condensing machinery is in operation and the vacuum gage shows the proper vacuum and that it is easily maintained; then be sure that the receiver is directly open to the atmosphere. This opening is usually a 1-in. or 1¼-in. pipe fitted with a globe valve attached to the lowest point of the receiver and is used as a bypass around the steam trap, when there is not sufficient pressure to cause the trap to operate, thus giving a positive drain to the receiver.

Then crack the throttle and use the starting bar to operate the valve-gear until the receiver pressure runs up to 20 or 25 lb. and the bypass blows freely. Everything else being ready, hook in the reach rod and admit the steam, leaving the bypass open until the engine comes up to speed and takes the load. Next go around and close the bypass and see that the receiver trap operates. Always maintain a pressure above the atmosphere in the receiver sufficient to drive all water out through the trap provided for that purpose. If the load falls off for any reason and the engine must be kept running, lower the steam pressure to get a late cutoff in the high-pressure cylinder sufficient to keep up the receiver pressure.

JOHN J. RAMSEY.

Wellington, Kan.

All compound engine receivers should be provided with two traps, a steam trap to operate with pressure above the atmosphere, as during normal operating conditions, and a vacuum trap when the receiver contains a vacuum.

A vacuum trap may be placed below the receiver so that the water will flow to it by gravity. When the water reaches a certain inlet in the trap, communication to the vacuum is closed and the trap is vented to the atmosphere, the water discharging into the air. This trap should also be connected to the exhaust line if there are any pockets that may collect water.

The engineer can readily connect a vacuum trap and a pressure trap to the receiver and have a valve stem extend to the floor line to enable him to control the trap according to operating conditions.

One of the engines in the writer's plant operates compound condensing under a varying load and at times has little more than friction load. When this condition occurs, we drop the boiler pressure until the cutoff on the high-pressure cylinder will give a suitable receiver pressure. This will allow the pressure trap to drain the receiver. This trap should be cleaned frequently because the oil from the high-pressure side will tend to clog it and prevent satisfactory operation.

If the engine is to run for long with a light load, it may be good engineering to take down the low-pressure side and carry the load with the high-pressure side if the piping is arranged to bypass the low-pressure cylinder; if not, it may pay to so pipe it.

The receiver relief valve should be given more than usual attention and should have a wire so connected that it can be raised from its seat each day.

P. E. MERRIAM.

Methuen, Mass.

Hammering Check Valves

What experience have readers of POWER had in remedying hammering check valves on heating systems where the hot water is returned direct to the boilers by means of an automatic pump and tank?

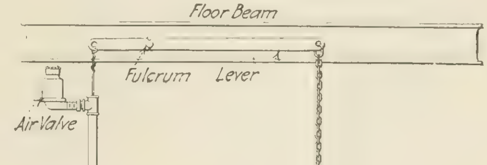
The writer's attention has been called to two cases lately in which trouble has been encountered from this action, although the piping was almost identical with that in a number of other systems which had given no trouble.

A. E. WALDEN.

Baltimore, Md.

A Simple Steam Trap

A steam trap being necessary on the outlet of a large heating coil, I decided to make one as shown in the sketch. I placed a tee in the line with a ½-in. brass riser 8 ft. long. A foot beyond that I placed a globe valve with threads filed off the stem; the pressure was under the disk. Overhead on a floor beam is a lever with one end attached to the top of the brass pipe and the other to a chain connected to the globe valve. The fulcrum is placed so as to make the leverage three to one. On the valve is a weight to hold the disk down and yet allow it to rise in case of excessive pressure in the coil when it will allow the valve to open like a safety valve.



HOMEMADE TRAP

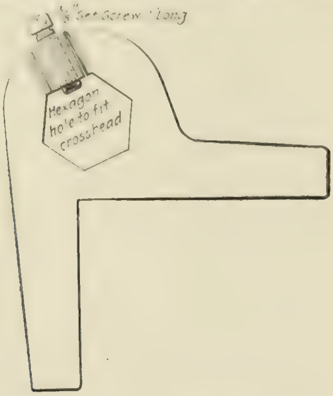
When discharging, steam reaches the brass riser, the expansion allows the globe valve to close. When water seals the riser, the valve is opened, allowing it to be discharged. This proportion of parts gives a total valve movement of about $\frac{3}{8}$ in. The air valve on top of the riser makes the changes more rapid and the whole affair, while simple and somewhat crude, works perfectly.

H. K. Wilson.

New Bedford, Mass.

Dog for Pump Piston Rod

The illustration shows a device for use on a Prescott piston-pattern, boiler-feed pump. The idea is to prevent the piston rod and the crosshead from being turned by the valve-actuating levers. As this type of crosshead has a hexagonal end the device is easily applied. This improvement also helps to hold the piston rod when tightening jam-nuts, etc.



W. E. Rough.

Chisholm, Minn.

Power-Plant Conditions in the South

I have read with becoming mortification of spirit the editorial bearing the above title in which you chant the obsequies of the isolated plant in the South. He died at the hands of the hydro-electric plant in the struggle for industrial supremacy. Was it murder or justifiable homicide?

Some months ago you published the rates at which power from the Hale's Bar development near Chattanooga is sold. These are supposed to be among the lowest of the hydro-electric rates, yet they make the cost of a horsepower some $20 for a 3600-hr. year. It would not take a phenomenal steam plant to beat that figure, especially if there were any use for exhaust steam, as for slashing.

The standing charges against a plant are usually assumed at about 12 per cent. A good steam turbine-driven plant can be put down for $50 per hp., entailing a standing charge of $6 per hp. per annum. The Hale's Bar development cost over $150 per hp. of maximum capacity, and at the same rate is subject to a standing charge of $18 per hp. The difference would pay the coal bill of a good steam-driven plant.

In addition, many hydro-electric plants have to maintain, as your editorial says, steam plants for stand-by or reserve service, so they have to carry the standing charges which the steam plant ordinarily has in addition to their own. Furthermore, the power delivered and collected for is considerably less than that generated, on account of line losses.

W. V. A. Powelson, a consulting engineer of New York, in an argument* opposing the charge to private parties of a rental by the government for the use of water powers, and in favor of grants in perpetuity, says that "many water powers have little or no commercial earning capacity in competition with coal," and that the number of water powers which are capable of producing power considerably cheaper than by coal is not very great.

If the hydro-electric developments of the South displace the isolated steam plants generally it will be because the steam plants are not as good as they should be, or those who are responsible for the change have not a full understanding of the facts and conditions.

Ralph E. Somers.

New York City.

Purchasing Coal on B.t.u. Basis

The government has definite specifications regarding the purchase of steaming coal in which the ash and moisture content as well as the heat value bear a definite relation to the price per ton. When bids are called for, each bidder's price is reduced to a common basis for comparison. Through three successive steps, taking into account ash, moisture percentage and B.t.u. value, the cost for 1,000,000 B.t.u. is determined. Although certain limits are established for sulphur content and volatile combustible matter, they are not taken into account in correcting the bidder's price.

The accompanying table shows the cost of 1,000,000 B.t.u. figured on the government basis, also the performance of the coal under actual operating conditions for nine different samples. The coal was tested in a plant of 1000 boiler horsepower, the boilers being of the water-tube type, with chain-grate stokers and a draft of 0.30 in. maintained over the fire by a 77-in. fan. According to the government method of calculation, sample No. 1 is the cheapest coal, but tests demonstrated that it was not suitable for the work at hand, and it was not the cheapest when the cost per kilowatt-hour was considered. The table is self-explanatory. The contractor who submitted sample No. 6 was awarded the contract. Samples Nos. 2 and 3, the only coals showing a lower cost per kilowatt-hour than No. 6, together with satisfactory furnace conditions, were rejected because the contractor had a reputation for slow delivery.

It would seem valuable, as a check on practical tests,

COST AND PRACTICAL TESTS OF COALS

			Practical Test Chain-Grate Stokers, Induced Draft		
No. of Sample	Kind Bit.	Cost of 1,000,000 B.t.u.	Cost per Kw.-hr.	Behavior of Coal	Remarks
1	N&S	$0.041	$0.021	Clinkered badly	Too large
2	P&S	0.043	0.0119	Good	
3	P&S	0.043	0.0126	Good	Dusty
4	N&S	0.046	0.0178	Clinkered	Excessive slate
5	N&S	0.047	0.0127	Clinkered	Excessive slate
6	P&S	0.051	0.0128	Good	
7	P&S	0.061	0.0125	Fair	
8	N&S	0.0645	0.018	Fair	Gummy
9	N&S	0.065	0.0153	Clinkered	Too large

N&S = Nut and slack; P&S = Pea and slack.

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*Senate Document 243, 63d Congress, first session.

that some relation be established between the price paid for coal and the heat value, ash content and moisture, but the attached table shows that it would be inadvisable to contract for a coal supply without testing out thoroughly, under actual operating conditions, different coals on the market most accessible to the plant in question. Again, as in the case at hand, there may be factors to be taken into account besides low cost of operation and clinkers. If previous experience has shown that certain contractors or mines are unreliable or unfitted to handle the business, they should be stricken from the list of bidders.

There comes to my mind a plant which during one year used a certain coal selected on a B.t.u. basis and fired under hand-stoked boilers. The ash was of such quantity and quality that as much labor was required to handle the ashes and clean fires as to handle the coal, to say nothing of damaged furnace walls.

P. J. Bryant.

Jeffersonville, Ind.

⁂

Getting Rope over Top of Stack

Several times within his experience the writer has had to place a rope over the top of a self-supporting stack. Sometimes it has been desirable to paint the outside of the smokestack and the rope running through the pulley at the top has broken or fallen. Frequently in isolated plants inconvenience is occasioned by this trivial accident.

There are several simple methods for getting a wire or a rope over the top of the stack. One method is to use an ordinary skyrocket with a cord attached, on the inside of the stack. By shooting the rocket up the stack the stick will fall on the outside, and pull a fine cord with it, which will in turn pull a larger one up until a rope of any size desired can be drawn up. It is an easy matter then for anyone to scale a stack with a rope that is extended up the inside, and down to the ground on the outside.

Sometimes in isolated places a skyrocket is hard to obtain at some seasons of the year, and then a much simpler method can be employed. It consists of erecting a cross-bow inside the stack and then shooting an arrow, or any other projectile, up the inside and let it fall on the outside, pulling a fine cord with it. In some of the larger cities, where steeple-jacks can be secured, this work can be delegated to them, but it will save much expense if the engineer in charge knows this little trick of getting the rope over the top of the stack.

Letson Balliet.

Tonopah, Nev.

⁂

Slip of Reciprocating Pumps

F. F. Nickel's communication regarding the slippage of reciprocating pumps, in the Jan. 6 issue, contains some excellent material for discussion.

First, the article states that "the rate of leakage is practically constant . . . If the slip at full capacity is 5 per cent., then at half capacity it will be 10 per cent." In my article on this subject, printed in the issue of Apr. 8, 1913, the curves showing the slippage of pumps do not bear out this statement. It is true that the slip increases when the speed of the pump decreases, but not in the simple ratio stated. I said that the rated capacity of the pump tested was reached when the piston speed was about 140 ft. per min. Using this as a basis, the following is a comparison of the results actually obtained with those which Mr. Nickel would expect to find:

Piston Speed	Tested Slip	Computed Slip
	150-lb. Discharge Pressure	
140	16	16
70	24	32
35	48	64
	10-lb. Discharge Pressure	
140	5	5
70	7	10
35	20	20
17½	45	40

This tends to prove that there are more things than simply the piston speed which govern the slippage of a pump.

Second, Mr. Nickel brings up the matter of testing small pumps by closing the discharge valve and admitting steam until the normal water pressure is obtained. The speed of the pump is then noted, and if it does not exceed a certain prescribed number of strokes, 1 per cent., the pump is considered to be in good shape as far as slip is concerned. The fault I find with this method is that it takes into account practically only the slippage past the plunger, largely neglecting the leakage past the valves. This procedure also does not reproduce working conditions, as the water is practically at rest and therefore does not offer the resistance nor possess the inertia which water in motion does.

The question of pump slippage is a broad and important one, and I think many of us would be interested in hearing its further discussion.

Mervin K. Baer.

Chicago, Ill.

⁂

Operation of the Delray Boilers

There appeared in the Dec. 30 issue an abstract of a paper presented before the American Society of Mechanical Engineers, by J. W. Parker, on "Further Operation of Large Boilers of the Detroit Edison Co." This paper is interesting, especially as it involves certain theories of hand-control in boiler operation, which appear at variance with established practice. Under the subject of regulation, with reference to CO_2 results, the following statement is made:

"As to furnace conditions, the firemen must judge by the CO_2 recorder, by the amount of air pressure necessary for any given boiler load, and also by the color of the gases as they pass over the first baffle and enter the top of the superheater pass."

There is no question of being able to judge the combustion by the CO_2 results, but to judge the boiler load by the air pressure is hardly comprehensible; for the resistance of the fuel bed governs the static pressure in the ashpit to a large extent. With the fire burning thin, the ashpit pressure is reduced, and *vice versa.* Therefore, the ashpit pressure rather indicates the thickness of the fuel bed, instead of the rate of combustion, providing the fans are running at constant speed.

With further reference to CO_2 results Mr. Parker says:

"It is not desirable to substitute automatic air and stoker control if a better CO_2 chart cannot be shown thereby. The danger is that the fireman will rely on the automatic device rather than study the conditions and control his fire intelligently. With the present hand control, excellent furnace conditions are being obtained and held. Observation of the furnace gases, as they en-on the uppermost pass from the top of the combustion chamber shows that the combustion of volatile gases is complete and that the operation is consequently smokeless. At the same time, the CO_2 charts give good results, 15 per cent. of CO_2 being common and the average being 13½ to 14 per cent.

My experience cannot be reconciled with this statement, inasmuch as both the boiler and furnace efficiency have not been taken into consideration. High CO_2 does not necessarily mean a large output per pound of coal. To illustrate this point, consider the operation of five boilers in a plant, and imagine a moment when the steam pressure is dropping, say, 2 lb. If all the firemen get after their fires, before they can recover the steam pressure, it will have dropped more, and the five fires will then have to be driven to regain the pressure, and a high CO_2 will be had. Almost invariably, the steam meter will show the boilers to have been run in excess of their most efficient steaming rate with a consequent drop in efficiency. Furthermore, the drop in steam pressure undoubtedly has been due to one fire or boiler trailing behind the others, which has thrown a momentary overload on the remaining boilers. As a consequence, there must be a continued loss on all boilers. On the other hand, when the fires are brought up to their proper condition, if the load should drop off slightly, the pressure will rise, and the firemen, nine times out of ten, will immediately start hand manipulation to check the combustion and the furnace efficiency falls off, due to the formation of CO.

The nearer the combustion can be kept constant with slight changes to keep the desired steam pressure, the better will be the results. Of course, the boiler needs some constant rate of evaporation, or nearly so, for the attainment of maximum efficiency. Therefore, the ideal condition must be at a point which represents a constant rate of combustion and of evaporation.

With automatic control of the air supply and outgoing gases, one is able to fix the best condition under which the boiler is to operate, and maintain it uniformly for all rates of steaming. There follows, therefore, a regulation with respect to the particular conditions within each boiler, such as the thickness of fuel bed and compensation for blow-holes and thin spots in the fire. A predetermined pressure is maintained in the furnace chamber for all rates of combustion and is accomplished by varying the ashpit pressure to meet the different resistances of fuel beds. Therefore, there is a constant quantity of air going through the fuel bed which adjusts itself to the requirements of steam. There follows, also, an even distribution of the load on the boilers, because equal quantities of coal are burned in each furnace—i.e., the regulation is such that each boiler is made to do its pro rata share of the total output of the plant.

My observation has been that, with automatic control, the firemen are made more efficient by giving them more time to watch operating conditions, and their minds are relieved from the numerous and burdensome conditions of hand control.

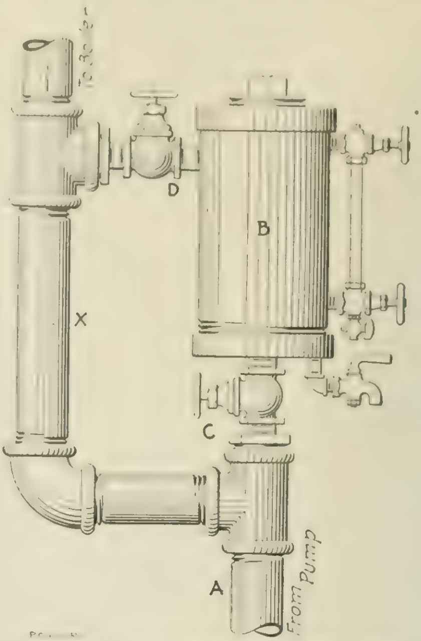
R. E. FOX, JR.

New York City.

[Mr. Parker was not discussing the subject in general, but merely stated the practice which had been found best adapted to the conditions at the Delray station.—EDITOR.]

High-Pressure Compound Feeder

The illustration shows a boiler compound feeder that should prove good in operation on the discharge pipe of the feed pump. The discharge pipe *A* from the feed pump is connected to a strong cylinder *B* by pipes *C* and *D*. The top of the cylinder is provided with a plug which can be removed to allow the compound to be placed in the cylinder. When the pump is in operation, the valve *D* is to be opened more or less, according to the amount of compound it is desired to feed. By placing a valve at *X* a positive feed of compound to the boiler could be had by closing that valve and opening valve *F* and running the pump slowly. Clear water will show in the glass when the compound is gone.



COMPOUND FEEDER IN PUMP DISCHARGE

JAMES E. NOBLE.

Toronto, Can.

* * *

Power-Plant Piping

The piping systems of steam plants in the United States and Canada are usually of markedly different design than those found in European countries. Although the manufacture of pipe and fittings here has been brought to a high standard, the use of certain fittings seems to have been neglected, even when the cost would not add materially to those usually employed. Some designers of steam plants apparently forget the advantage of giving steam free flow through a steam line and that right-angle turns are to be avoided.

I call to mind a steam plant in Budapest in which the steam pipe line was made with easy curves at every turn. There were six engines and the steam supply came to the center of the header feeding the engines. Where the pipes came through the boiler-house wall, care had been taken to avoid openings around them. There were no connecting doors from the engine room to the boiler house and the boilers were stoked at the end farthest from the engine room. This construction precluded the possibility of dust, ashes and dirt working into the engine room.

The piping was of copper. On entering the engine room the main pipe branched right and left in the shape of a Y to supply the engines; these branches were made with easy curves. The outlet to the first and second engine on each branch, instead of coming out at right angles from the main supply pipe, was made by brazing in the pipe at an angle of about 60 deg. At this pipe the main supply pipe was reduced in size by a long cone and beyond the second outlet the pipe was again reduced and led to the third engine with a long-radius curve. At the end of the supply main another pipe was brazed on from the under side and, passing through and under the floor to the boiler room, discharged into a hotwell. This method was repeated on the second group of engines to the left.

Extreme care had been taken in insulating the steam pipes, the one running from the boilers to the engine room being thickly insulated at the larger end, but gradually decreased as the pipe size was reduced. The pipes at the extreme ends of the steam mains leading to the hotwell were fitted with a stop valve close to where the last engine pipe branched off. These two pipes were to drain the water from the steam main before starting up. Straightway valves were placed in the main supply pipe where it branched right and left, after entering the engine room, for cutting out either branch if one of the two groups of engines were idle, to prevent loss by radiation and condensation.

I do not recall the exact mechanical construction of the throttle valves, but the idea was that before a throttle could be opened it was necessary to turn back a lever which, when the valve was closed, folded over the handwheel of the throttle with a cap. In turning this cap out of the way a drain valve, piped above the valve seat, was opened, which drained out any water that might have collected; this water was returned to the hotwell in the boiler room.

This piping layout and other arrangements are not usually seen in America. The boiler room is generally just outside the engine room with sliding doors between, and comparatively little attention is given to making them dustproof. The piping in America would undoubtedly be of steel or wrought iron; they are cheaper and answer as well as copper, but after entering the engine room the main supply is frequently found to branch from a tee or elbow and the outlets to the engines are made in the same way. This is objectionable. Why are not more Y-connections used where the main steam pipe enters the engine room, and easy bends and Y's employed instead of tees and elbows? Long-radius bends are employed extensively in the later installation between the boilers and headers, and between the headers and engines, a decided improvement upon former practice.

In the Budapest plant I was struck with the method of arranging the intake to the suction of the air compressors. In America, air compressors usually take air from the engine room, but in the plant referred to, air ducts passed through the roof of the engine room about 12 ft. and, instead of being guyed by unsightly wires, the 12 wooden air intakes, supported horizontal pieces over which vines were growing, giving a neat and artistic effect.

W. D. Forbes.

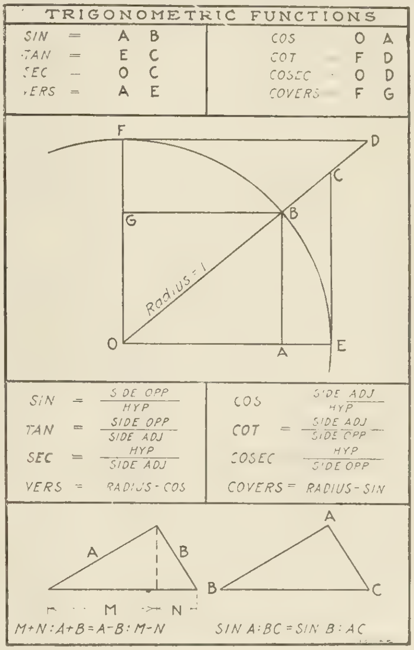
New London, Conn.

[It is true that y-connections in steam lines are infrequently used in this country, but it is the prevailing practice to use long- and short-radius fends, where possible, instead of elbows and tee connections. Furthermore, steam piping is eliminated from the engine room as much as is possible.—Ed.]

Trigonometry Data Sheet

Supplementing the lessons on trigonometry in the Study Course, the accompanying data sheet should be of service for quick reference.

It was got up by the writer several years ago; the original is a tracing which is kept in a ring-binder; blueprints being made from it as required. These blueprints are pasted on the inside of the covers of handbooks, such as "Kent," and the handbooks published by the manufacturers of structural steel. These handbooks are usually kept within reach, so the solution of a problem in trigonometry would be a simple matter for one who does not have the formulas indelibly impressed upon his memory.


TRIGONOMETRIC FUNCTIONS

SIN = A B		COS O A	
TAN = E C		COT F D	
SEC — O C		COSEC O D	
VERS = A E		COVERS F G	

SIN = $\frac{\text{SIDE OPP}}{\text{HYP}}$

TAN = $\frac{\text{SIDE OPP}}{\text{SIDE ADJ}}$

SEC = $\frac{\text{HYP}}{\text{SIDE ADJ}}$

VERS = RADIUS - COS

COS $\frac{\text{SIDE ADJ}}{\text{HYP}}$

COT = $\frac{\text{SIDE ADJ}}{\text{SIDE OPP}}$

COSEC $\frac{\text{HYP}}{\text{SIDE OPP}}$

COVERS = RADIUS - SIN

M+N : A+B = A−B : M−N

SIN A : BC = SIN B : AC

Trigonometry Data Sheet

It will be noticed that in the equations for the functions expressed as ratios, instead of using the letters *AB, OA, OB*, etc., to represent lines, they are designated as "side opposite," "side adjacent," "hypotenuse," this being more concrete and better adapted to the memory.

Underneath is found the method of solving triangles other than right-angled triangles.

C. O. Sandstrom.

Kansas City, Mo.

Misstatements Regarding Diesel Engines

Technical Paper 37, issued by the Bureau of Mines, and entitled, "Heavy Oil as a Fuel for Internal Combustion Engines," contains some questionable information on oil and a two page description of the Diesel engine, by O. P. Hood, chief mechanical engineer, in which there are some glaring misstatements, some of these are as follows:

1. "The heat is thereby generated by a more nearly constant temperature and does not reach the high temperature or pressure of the explosion engine."

The oil engine is equipped in many cases with a relief valve which is set for 800 lb. The explosion type rarely has a pressure of more than 300 lb.

2. "Another peculiar feature of the manner in which this engine uses heat is the compression of the air for the combustion to such a degree that the heat developed thereby approximates the temperature obtained by the subsequent burning of the fuel."

The compression temperature is 1000 deg. F. and the combustion temperature around 2500 to 3000 deg.

3. "It (the temperature of compression) also causes the spontaneous ignition of the charge of the fuel, although that is not the chief reason for the high compression."

The reason for the high compression of the Diesel is to produce ignition of the charge.

4. Relative to the ignition system—"so that the engine in this subject is much simpler than the explosion engine."

It is only necessary to compare the fuel valves of a Diesel engine, with their at present unsolved troubles, and a spark plug and timer for an engine of the explosion type.

5. "In general appearance these engines are like the explosion engines, although not built so heavily."

The fact of the Diesel engines having such high pressures means that they must be heavily built.

6. Referring to fuel injection the statement is made that it is injected "at such a rate as will maintain an approximately constant temperature while burning."

As a matter of fact the Diesel engine has a constantly rising temperature during injection.

It is a waste of money to have anything of the sort published and besides it may do harm by giving false impressions.

John F. Wentworth.

Quincy, Mass.

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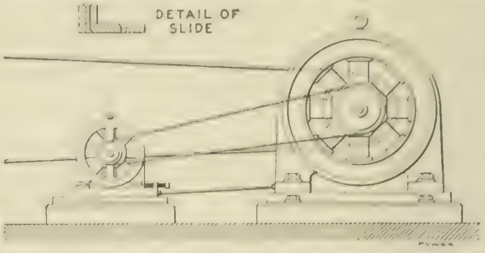
Belted Exciters

Probably the most vulnerable point in a belted alternator and exciter unit is the pulley end bearing of the exciter. Much inconvenience is experienced with unequal shrinkage and expansion of the main drive and exciter belts. When the main belt is tightened with the unit in use it is necessary first to slack the exciter belt, attended by possible slippage, or to throw undue strain upon the exciter bearing while the main belt is tightened and before the exciter can be moved a corresponding amount. A simple method for overcoming this difficulty is suggested as its more universal use seems warranted. The idea has been tried and found effective and convenient.

Instead of fixing the exciter base firmly to its foundation, it can be mounted upon strap-iron slides with sides projecting upward along the sides of the exciter base. A cross-section of such a slide is shown in the upper left-hand corner of the illustration. This slide permits the whole exciter to be moved upon the foundation, yet kept in alignment. A rod is now connected from the exciter base to the alternator itself; this can be fastened in any convenient manner. The length of this rod should be adjusted for the belt so that the stretch will be taken up by the adjusting screw of the exciter unit. If the exciter belt is new it is placed upon the pulleys and the exciter slid upon its base until it is at the extremity toward the alternator. The exciter base is then moved to tighten the small belt, the exciter aligned, the rails placed and the length of the connecting rod determined. The rails and exciter foundation should be long enough to provide for the full travel of the alternator upon its base.

A modification of this method provides a rod directly from the alternator to the exciter, allowing the exciter base to be bolted down, the exciter sliding upon it as the main belt is adjusted. A turnbuckle must then be placed in the rod connecting the machines to provide for adjustment of the exciter belt.



Belted Exciter with Rod between It and the Generator

Chicago, Ill. Gordon Fox.

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Testing Ammonia Piping

In the Jan. 6 issue, Gilbert Crawford, Jr., describes a method of testing direct-expansion coils in a freezing tank. While it evidently was a success in his particular case, I would not recommend it as good practice. It is not a sufficient test, and should only be used in an emergency, such as confronted Mr. Crawford.

To properly test the coils in a freezing tank, an air pressure of from 175 to 200 lb. per sq.in. should be applied, using either the ammonia compressor as an air compressor or a separate air pump. After the pressure has been applied, brush each joint with soapy water and if a leak exists, the air escaping around the threads or between the flanges will form a soap bubble which can be readily seen. After every joint has been gone over in this manner, fill the tank with water and again apply the air pressure, watching the surface of the water for air bubbles. Air pressure should be left on the coils over night and the gage read the following morning to see how much the pressure has dropped.

As a final test, the air should be blown out, which incidentally will clear the coils of scale, and a vacuum test applied for two or three hours, carefully watching the gage to see if air leaks in and reduces the reading. Sometimes the vacuum test will reveal small leaks that pressure does not indicate.

Jacksonville, Fla. C. T. Baker.

Inquiries of General Interest

Speed of Rotor without Induced Current—Would the rotor of a three-phase squirrel-cage induction motor come up to speed if the copper bars of the rotor were removed?

W. B. F.

No, for there would be no induced current set up in the rotor.

Draft for Haulage at Different Speeds—What would be the relative drawbar pull hauling 4800-lb. loads up a 10 per cent. grade at the rate of 600 ft. per min. as compared with 800 ft. per min.?

J. H. S.

Neglecting air resistance, after the speeds become constant, the drawbar pull would be practically the same.

Testing Pump Valves—How are the suction and the discharge valves of a pump tested for leakage?

T. P. G.

By putting full water pressure on the suction and the delivery valve decks while the pump is idle and examining for leakage of the suction valves from the pump cylinder through the suction valves and for any leakage of the discharge valves back into the pump cylinder.

Temperature of Feed Water from Closed Heater—To what temperature can boiler feed water be heated in a closed heater by steam supplied at 1-lb. gage pressure?

G. C.

The temperature of steam at 1-lb. gage pressure is 215.4 deg. F., but with continuous boiler feeding the average temperature of water supplied to heaters, and with the usual proportions of clean heating surfaces, the water is generally heated to about 205 deg. F., depending on the temperature of the supply, the proportion and the cleanliness of the heating surfaces and the heat lost by radiation from the shell of the heater.

Capacity of Brick Chimney—What would be the boiler-horsepower capacity of a brick chimney 110 ft. high and having a least diameter of 48 in.?

J. G.

For ordinary conditions, the number of boiler horsepower for which a chimney is appropriate may be found by the formula

$$\text{hp.} = 3\tfrac{1}{3}\,(A - 0.6\sqrt{A}) \times \sqrt{H}$$

in which A = the cross-sectional area of the smallest part of the flue in square feet and H equals the height of the chimney in feet, according to which a chimney of the dimensions quoted would be suitable for 365 boiler-horsepower.

Kilovolt-Ampere—What is the definition of "kilovolt-ampere" and why is it used on nameplates of alternating-current apparatus instead of kilowatts?

T. H. Y.

One kilovolt-ampere is the product of one volt and one ampere times 1000, or the amperes in a circuit times the volts divided by 1000 gives the kilovolt-ampere capacity of that circuit. This also applies to kilowatts in direct-current practice, but in alternating-current work, the kilowatts are equal to the volts times the amperes times the power factor divided by 1000. A machine might carry 100 amp. and 220 volts at 80 per cent. power factor, which would be equivalent to 22 kilovolt-amperes, though delivering only 17.6 kw. Manufacturers rate their alternating-current apparatus in kilovolt-amperes to signify how much load the machine will carry under all conditions.

Reversing Direction of Engine Rotation—How can the direction of rotation of a D-slide-valve engine be reversed without removing the valve chest cover in resetting the valve?

E. T.

Approximately the same setting of the valve for reversed rotation is to be obtained by giving the eccentric the same angle of advance for the new direction of rotation. This can best be done by indicating the engine and setting the eccentric to a position on the shaft which will give indicator diagrams which are correct for the new direction of rotation; or the same angle of advance of the eccentric for opposite direction of rotation may be found by marking a point on the side of the shaft which is intersected by a radial line drawn on the side of the eccentric opposite that point of the eccentric furthest from the center of the shaft. The angle between this line and the radial direction of the crank will be the total angle the eccentric is in advance of the crank. Then place the crank on either dead center, loosen the eccentric from the shaft and turn it around the shaft in the first direction of rotation of the engine until the radial line is in line with the eccentric rod.

The distance the eccentric has thus been turned will be one-half of the total distance it is to be turned on the shaft and set for reversing the direction of rotation with the former angle of advance of the eccentric.

Size of Boiler—How is the manufacturers' horsepower rating computed for a flush-ended return-tubular boiler 66-in. diameter by 16 ft. long with ninety-six 3-in. diameter flues?

J. D. A.

The manufacturers' horsepower ratings of sizes of externally fired boilers are based on an allowance of 10 sq.ft. of heating surface per horsepower.

With ordinary brick setting the heating surfaces of a flush-ended return-tubular boiler of the dimensions given would consist of:

(A) The area of one-half of the shell, i.e.,

$$\tfrac{1}{2} \text{ of } \frac{66 \times 3.1416}{12} \times 16 = 138.23 \text{ sq.ft.}$$

(B) The internal area of the 3-in. tubes, i.e.,

$$\frac{8.74 \text{ in. circumference}}{12} \times 16 \times 96 = 1118.72 \text{ sq.ft.}$$

and

(C) The heating surface of the heads, approximately equivalent to the area of a circle 66 in. in diameter minus twice the external cross-sectional area of the tubes, i.e., the area of 66 in. or 5½-ft. diameter being 23.758 sq.ft. and the external cross-sectional area of a 3-in. tube being 0.0491 sq.ft., the net heating surface of the heads would be approximately,

$$23.758 \text{ sq.ft.} - 2\,(0.0491 \times 96) = 14.33.$$

Adding A, B and C the total is

$$138.23 + 1118.72 + 14.33 = 1271.3 \text{ sq.ft.}$$

the manufacturers' horsepower size of the boiler would be

$$\frac{1271.3 \text{ sq.ft.}}{10} = 127.13 \text{ horsepower.}$$

Efficiency with and without Economizer—When using an economizer a boiler plant has an efficiency of 64 per cent. The water entering the economizer contains 78 B.t.u. per lb. above 32 deg. F., and upon entering the boiler it contains 176 B.t.u. per pound above 32 deg. F. The boiler evaporation is 12,000 lb. of water per hr., containing per lb. 1120 B.t.u. above 32 deg. F. The heat of combustion of the coal is 14,000 B.t.u. per lb. of coal. How many pounds of coal are burned per hour and, with the same efficiency of the boiler and using the same coal, what would be the efficiency of the plant without use of the economizer?

J. P. C.

While using the economizer the heat per hour received by the water would be

$$(1120 - 78) \times 12{,}000 = 12{,}504{,}000 \text{ B.t.u.}$$

and the heat realized would be 0.64 of 14,000, or 8960 B.t.u. per pound of coal, therefore the coal used would be

$$\frac{12{,}504{,}000}{8960} = 1395.5 \text{ lb. of coal per hr.}$$

Without using the economizer there would be a loss of 176 − 78, or 98 B.t.u. per pound of water fed to the boiler and, with the same efficiency of combustion, each pound of water evaporated would require burning

$$1 + \frac{98}{1120 - 78} = 1.094 \text{ times as much coal.}$$

Hence only $\frac{1}{1.094}$ as much heat of the coal would be realized and the efficiency of the plant would be reduced to

$$\frac{1}{1.094} \text{ of 64 per cent., i.e., } 58\tfrac{1}{2} \text{ per cent.}$$

Engineers' Study Course

The Slide Rule--I

Were one to take two rulers, such as are shown in Fig. 1, and place them with edges touching with the left end of one on, say, the "3" of the second, it is clear that under the "2" of the first would come the "5" of the second. That is, a reading on the second would give the sum of the digits indicated. And so, any addition could be performed by such rulers.

It is only a step to a multiplying set of rulers. Since 0 times anything is 0, omit a zero point on the scales, and begin them at "1," and taking any arbitrary space to the right from "1," make a mark and call it "2." Slide one rule along the other until the "1" of one scale comes opposite the "2" of the second and under the "2" of the first make a mark on the second, calling it "4." Now slide the "1" on the upper scale to "4" and under "2" mark "8." By an extension of this process a rule can be made by which multiplication and division can be done, just as addition and subtraction could be with two ordinary rules, were these processes long enough to require aid of this sort.

Incidentally, logarithms furnish a ready means of graduating such a rule so that the tedious cut-and-try method is unnecessary. However, let no one think that a knowledge of logarithms is necessary to work a slide rule. Almost any who will take a rule and follow the directions can work out the problems explained later whether he knows logarithms or not, and will find the slide rule a brain-and-time-saving shortcut for such work.

The ordinary rule, Fig. 2, consists of four scales, *A, B, C* and *D*, *B* and *C* being movable, *A* and *D* being fixed, and a runner with a hair line. The only difficulty in using the rule is to banish all disturbing thoughts about the decimal point. That is, the "1" of the slide rule represents 0.1, 1, 10, 100 or 1000; the "2" represents 0.2, 2, 20 or 200, etc. The decimal point is merely an incident; it is the absolute value of the figures that counts.

On the lower scales, *C* and *D*, it will be seen that the space from "1" to "2" is divided into 10 spaces, each of which is again subdivided into ten. The larger spaces represent "1.1," "1.2," "1.3," "1.4," etc., or these figures multiplied by 10 any number of times i.e.,; they may represent 1100, 1200, 1300, etc. The smaller spaces represent proportional parts of the larger divisions; thus the sixth line after the "1.2" line will be 1.26 (or 12.6, etc.).

If it is necessary, as it usually is, to estimate more closely, one must interpolate. That is, 1.005 would be got by setting the hair line of the runner halfway from "1" to the first line; 1.001 would be found by guessing at one tenth of the first division. 1346 would be found by going up three of the main divisions from "1" to "2," giving 1300, then up four small divisions, giving 1340, then approximating six-tenths of the distance to the next line, giving approximately 1346.

The same is true with the higher numbers, "7" to "8," "8" to "9," etc., except that as will be seen by looking at the rule, the intervals between them are smaller, and there are on scale *D*, for instance, only 20 spaces between "9" and "10." It would, therefore, be necessary to estimate anything, except even twentieths, after the second figure here. Thus, 90.4 would be four-fifths of the distance from "9" to the first line after it.

The *A* and *B* scales on some rules are graduated from "1" to "10" and from "10" to "100." In others they run from "1" through "9" to "1" again and from "1" through "9" again to "1." The scales will, therefore, be referred to as the left-hand *A* scale, or to the left-hand "1," and the right-hand *A* scale, or the right-hand "1," although on some rules the right-hand "1" is marked "100." (Forget the decimal point.)

With this much preliminary, the best thing to do with a slide rule is to go ahead and use it, and learn by experiment. Multiplication is the easiest process. To multiply 1.3 by 3 on scales *C* and *D*, set the hair line of the runner over 1.3 on *D* and bring the left-hand "1" of *C* opposite it. The product (3.9) can then be read off on *D* opposite 3 on *C*.

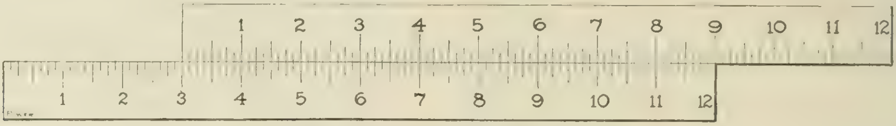


Fig. 1. Adding with Two Rulers

There are numerous rules to keep the decimal point in mind as one works, but many find them all burdensome, and likely to be followed erroneously, and prefer to determine the decimal point after getting the answer, for it can usually be told whether an answer is 10 times too large or too small. Think of the slide rule as a person who would answer 8 whether he was asked what is 2 × 4; or 20 × 40; or 200 × 4000. So long as one knew of his personal peculiarity, and allowed for it, it would result in no difficulty. However, if one wants a rule for determining the decimal point, a fairly simple one is as follows:

In multiplication, if the slide projects to the left when the answer is found, add the whole-number places in the multiplicand and multiplier to get the number in the product. For division subtract the places in the divisor from those in the dividend to get those in the quotient. If the slide projects to the right when the answer is found, for multiplication do the same as before and then subtract one, or, for division do the same as before and add one. In other words, add one less for multiplication and subtract one less for division.

It will be found by experiment that if the hair line of the runner be set on 3 of *D* and the left-hand "1" of *C* be placed opposite it, that 3.9 will be found opposite 1.3 on *C*, which is to be expected, as 2 × 3 is equal to 3 × 2. The following, then, may be given as a rule for multiplying on the slide rule:

Set the "1" of the movable scale opposite one of the numbers on the fixed scale; the product will be found on the fixed scale opposite the other number on the movable scale.

Study Questions

1. Using the slide rule, multiply 17,000 by 0.0093.
2. Divide 0.0316 by 273.
3. Solve $\frac{605 \times 921}{437}$.
4. Write the equation and solve with the slide rule the following problem. What is the horsepower of a 10x10-in. engine running at 346 r.p.m., when an indicator diagram shows a mean effective pressure of 26.7 lb.?
5. The heating surface of a boiler is 920 sq.ft. and the grate area 27 sq.ft. If the coal consumption is 10 lb. per sq.ft. of grate area, what is it per square foot of heating surface?

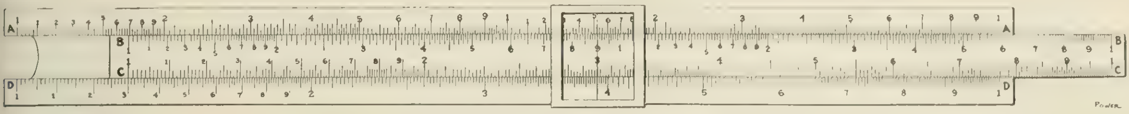


Fig. 2. The Slide Rule for Multiplying and Dividing

However, it may be noted that there is some mechanical choice in the above problem. If the smaller number be taken on the fixed scale, the slide projects less from the rule than if the larger number be taken there, and it will be found that the rule is less likely to be disturbed by accidental jolts, the less there is of the slide projecting.

As will be noticed as soon as any experimenting is done with the slide rule, the lower scales, *C* and *D*, are graduated more finely than *A* and *B*, or what is the same thing, the corresponding numbers are further apart. For this reason it is easier to read and interpolate on the lower scale, and in general it is preferable to use the lower scales for everything except roots and powers.

However, the lower scales have some unpleasant peculiarities. Suppose it is wished to multiply 2.6 × 45. If the hair line of the runner be set on 2.6 of scale *D*, and the left-hand "1" of scale *C* be brought opposite it, 45 on scale *C* will be found out in space. (Try this.) But this does not signify that 2.6 cannot be multiplied by 45 on scales *C* and *D*. Shift scale *C* end for end, setting the right-hand "1" (or ordinary "10," for they are the same on the slide rule) opposite 2.6 and opposite 45 on *C* is found 117 on *D*.

It may here be noted that the slide rule furnishes a set of tables. For instance, when the left-hand "1" of *C* is set on 26 of *D*, on *D* under the "2" of *C* is found 52, under the "3" of *C* is found 78. Resetting the rule, end for end; i.e., right-hand "1" of *C* on 26 of *D*, on *D* under "4" on C, is found 104, etc., i.e., a table of 26's is given in this way. This point will be reverted to later, but it should be seen immediately that if a larger number of multiplications are to be made, they can usually be performed with one setting of the rule, or at most two.

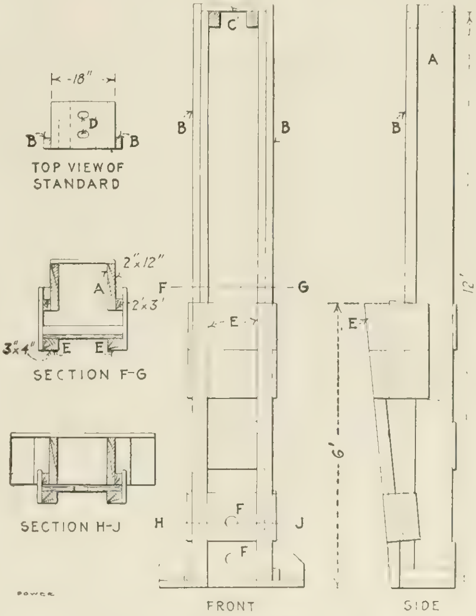
Division is the opposite of multiplication. To divide 962 by 37, on scale *D*, set the hair line of the runner on 96 and a little over, estimating two-fifths of the next small space; bring 37 on *C* opposite it. The quotient 26 will be found on the *D* scale opposite the "1" of the *C* scale.

In the next lesson will be explained how to get the squares and cubes, and the square roots and cube roots of numbers on the slide rule, with further hints on tables and on manipulation.

Handy Lifting Jack

By Robert C. H. Heck

Several years ago, the writer installed a small power plant in which the main piping was hung close to a low ceiling. This piping was made up ready for bolting together, the 5-in. high-pressure line with screwed-on flanges and flanged fittings; the 8-in. exhaust line (which had a number of branches) was in sections with flange unions. The heaviest sections ran from 500 to 800 lb. in weight, and a one-ton triplex block had ample lifting capacity; but there was no head room in which the block could be hung above the position of the pipe to pull it up into place.



Homemade Lifting Jack

To meet this condition a special lifting jack was devised so arranged that it could be placed beneath the pipe and lift, the hoist block supplying the needed lifting power. As outlined in the figure, it was made with an upright frame or standard *A*, made of two pieces of plank with crossbars at the top and bottom and some cross bracing on the back below mid-height. Along the outer front edges were fastened two guide bars *BB* of light scantling. The hoist block was hung at *C*, by a rope sling through the holes *D* in the top of the crosspiece.

The slide *E*, the construction of which is evident from the drawing, can swing in against the standard (dotted position) or outward against the guides *BB* (full lines), when its top forms a projecting shelf upon which a load can be placed.

The scheme is to lay the section of piping in front of the jack and lift it from the floor by hooking into a rope sling around it. It is hoisted upward along the front of the slide *E*, which swings in so as to offer as little resistance as possible. When the pipe is above *E*, that lift is swung out and the pipe lowered upon it. Then the hoist chain is run down and hooked into a sling fast to the slide *E* at the holes *FF*; and by raising *E* the pipe can be lifted to or above the top of standard *A*, and held there till secured by its permanent fastenings and supports.

If the jack is leaned forward a little, there will be less drag against its front and it can be steadied by running a couple of light guy ropes back from the top to the nearest column, window or machine.

The real merit of the scheme is the combination of the partial plain lift from above, the remaining lift being beneath the load.

⁂

Superheating Steam in Locomotives

In a paper on the foregoing subject, presented before the Institution of Civil Engineers of Great Britain, by Henry Fowler, Jan. 13, 1914, it was stated that the chief advantage claimed for the use of superheated steam in locomotives is the economy in coal consumption. On the Midland Ry., a number of trials were made to ascertain what this is with the various types of engines, the comparison being made on the consumption per ton-mile under circumstances as nearly comparable as possible.

These trials show that a saving of 23 per cent. in the coal consumption and of 22 per cent. in the quantity of water used, was obtained in one case, while in another, where the difference between the locomotives was solely in the superheater, the saving of coal was as high as 30 per cent. This high figure was probably due to the engine which used superheated steam having more reserve of power than the one employing saturated steam. From diagrams of these two engines it can be shown very clearly how much more fluid superheated steam is than saturated.

Experiments have been carried out to ascertain the effect of superheating the steam supplied to the high-pressure cylinder of a three-cylinder compound locomotive, and it has been found that a saving of coal of 25.9 per cent. and of water of 22.3 per cent. has resulted when comparison is made with a similar engine using saturated steam. In tests carried out with freight engines, the coal saving has been from 14.3 to 18 per cent.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Sampson W. Moon has patented an electric safety razor. Great! Like his prototype of old, this modern Samson has run down the pillars of the Temple of Behindhand and boosted us old barnacles up into the light of progress—the Moon-light of progress, in a manner of speaking. Can we then be shaved in bed while we sleep, the operation being timed to completion when our alarm clock tolls the doleful hour of rising? How 'bout it, Sampy?

⁂

It's just as practical for the Navy to operate its own oil lands as for a railroad to operate its coal lands. Secretary Daniels may have trouble in finding available fields, but he's on the right trail.

Suggestion! Why not get Otto Edler von Graeve and his little guessing stick, the divining rod, to locate an oil field near a navy yard or a seacoast? Perhaps oil is not susceptible to the Edler's radioactivity, although oil waves flow up from underground when found.

⁂

The Panama-Pacific Exposition buildings will need over a thousand tons of glass. My gollies! what if our suffragettes get the smashing habit along about 1915?

⁂

Our friend Vilhellum of Germany has sent his greetings over the 4062½ miles of wireless to Brother Wilson at Washington. The new Goldschmidt system wave speed is 196,000 miles per second. Some swift talk!

⁂

"Curing an Isolated Village of Loneliness," is the title of the leading article in the Jan. 29 "Iron Age." Sounds real good; but what's the remedy, importing a fresh load of eligible young bachelors or exporting the old maids? If any of the last-mentioned take exception to this harsh classification, we apologize here and now.

⁂

The Dodge Manufacturing Co. has a new (to us) dodge—it says it "treats an employee like a customer." President Melville W. Mix says "Bosh!" to the man who claims there's no sentiment in business. Here's another chance for that divining rod. How many employees expect or want such treatment? How many employers use it?

⁂

The most perfect pump in the world runs night and day without a stop, needs no repairs and lasts a lifetime; in an hour it pumps 956.25 lb., in a year 5,748,750 lb., its normal life is 70 years, in which it pumps more than 201,206 tons, and 30 engines would be required to haul that weight. It's the human heart.

⁂

Prizes of $120,000 will be awarded at Paris for the best stabilizer of air craft. Among the entries are the Sperry Gyroscope Co. and Glenn Curtiss. Here's hoping that the Yankees bring home the bacon! Anything that will make the airship stay up after it goes up, right-side up, can make the Parisians come up if it comes down right-side up.

⁂

A busy office manager has a miniature quilt of many colors on his desk, and when his eyes become tired from the white paper he rests his gaze on these colors. Wouldn't this carry you back to the quilts grandmother used to make?

⁂

They're a merry lot in Pittsburgh. The telephone folks are telling subscribers to "Smile when you phone; a frown has spoiled many a call." Let us assume, as Doc. Inquiries would say, that you met a chap you hadn't seen for years; and you just couldn't get away. You telephone the missus (and smile) that you're making a test at the plant that night; can't come home till 10:59. And friend Chap and you feed up, and take in a show, and then some more feed, then a bit of lubrication (and wifey, coming home from meeting, sees you going into the Café Mecca, the Beaux Arts, or Scully's (whichever you call it in your town) and then—About 10:58 you phone to the missus that the "test" is over—Smile? Wow! it can't be done.

The Induction Motor--VII

By F. A. Annett

The Repulsion Motor

From the general appearance of the windings, the stators of various repulsion motors are similar to that shown in Fig. 53, Part 6,* the number of poles being indicated by the winding itself.

The rotor has a winding similar to that of a direct-current machine; see Fig. 62, which shows the rotor of a Westinghouse repulsion motor. On this armature, however, the commutator is vertical and not horizontal, as in the direct-current machine. At starting, short-circuited brushes are pressed against the commutator, and after the motor has attained nearly synchronous speed a centrifugal governor, located within the armature, acts and presses a short-circuiting device against the commutator, short-circuiting all the armature coils. At the same time the brushes are raised from the commutator and the machine operates as a squirrel-cage induction motor.

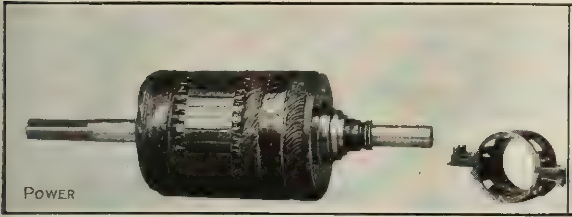


Fig. 62. Rotor of the Westinghouse Repulsion Motor

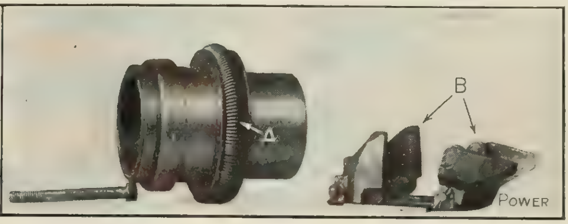


Fig. 63. Short-Circuiting Device and Governor Unassembled

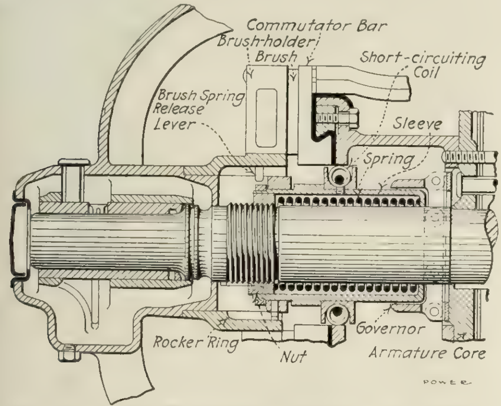


Fig. 64. Short-Circuiting Device and Governor Assembled

Fig. 63, *A* and *B*, show the short-circuiting device and governor respectively. The short-circuiting device consists of a steel sleeve, carrying a short-circuiting coil or spring of helical phosphor-bronze inside of which is a ring of flexible copper shunts. The governor *b* is made up of two weights so hinged that they will be thrown apart by centrifugal force as the motor comes up to speed; it rests against the rotor core and is kept in place by dowels. The short-circuiting sleeve is pressed against the governor by a spring and the whole is retained in place by a nut threaded on the shaft. Fig. 64 is a cross-section through the commutator end of the rotor, indicating the position of the various parts. When the governor weights are thrown out from the shaft they will push the spring sleeve toward the commutator and with it the short-circuiting coil, which will be forced under the commutator, as previously described.

Fig. 65 shows the rotor of a Wagner single-phase repulsion induction motor. This also employs a vertical commutator and short-circuited brushes at starting. Part of the governor spring and the sleeve that raises the tension springs on the brushes, also the adjusting nut on the shaft, can be seen beyond the commutator. To operate the short-circuiting device and raise the brush springs, two types of governors are employed. On the small sizes, the governor consists of two semicircular disks mounted on the back end of the rotor. One end of these disks is made fast; the other is free to move through a slot as indicated in Fig. 66. These disks are so connected to the short-circuiting device that when they are thrown outward by centrifugal force they push the short-circuiting device out toward the commutator. On the large-size motors a governor is employed, as shown in Fig. 67. Two weights are mounted on the shaft within the rotor, and as the motor is accelerated, the weights are thrown outward, the effect being the same as described for the other governors.

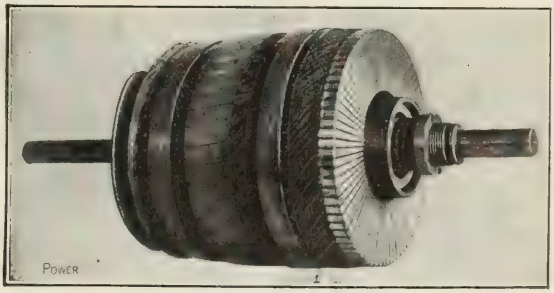


Fig. 65. Rotor of Wagner Motor

The Bell Electric Co. builds a repulsion motor with a horizontal instead of a vertical commutator; Fig. 68 shows the general appearance of the rotor. The governor and short-circuiting device are mounted at the outer end of the shaft. The governor *A* consists of two weights

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*Jan. 20 issue.

connected to a collar, held in place by set-screws. The short-circuiting device *B* is a steel disk which can move freely on the shaft and when the rotor is at rest it is held away from the commutator by a spiral spring in a sleeve within the commutator. Inside the steel disk is mounted a thin phosphor-bronze radial ring, segmented on its inner edge and sprung away from the disk so that when forced against the commutator by the governor, when the motor comes up to speed, it will make good contact. In this type of motor the brushes are not raised from the commutator after the rotor has been short-circuited, but this is not necessary, for after the commutator has been short-circuited the brushes cease to carry any current, and whatever sparking may have occurred at the brushes while starting will cease; therefore, the wear on the commutator is very small.

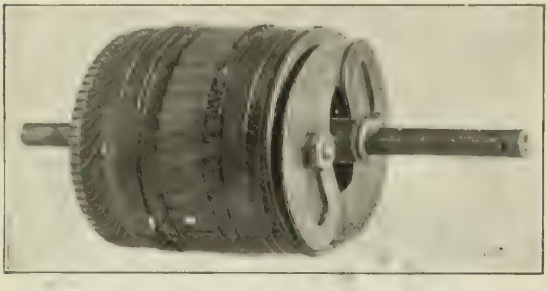


FIG. 66. SHOWING DISKS ON END OF ROTOR

The motors just described, when connected directly to the line at rated voltage, start with 250 to 300 per cent. of full-load current and develop from 250 to 350 per cent. of full-load torque. Using a starting rheostat full-load torque can be developed with about 125 per cent. full-load current. As described in Part 6, by shifting the brushes to the right or left of the stator field axis, the direction of rotation is determined. The normal running position for the brushes is when they are displaced from the stator field axis by about 15 or 20 electrical degrees. The position is always indicated by a scale, mounted on the rocker arm, with the two running positions indicated. If the motor is not turning in the proper direction, the brush-holder rocker arm should be shifted to the reverse position as indicated on the scale.

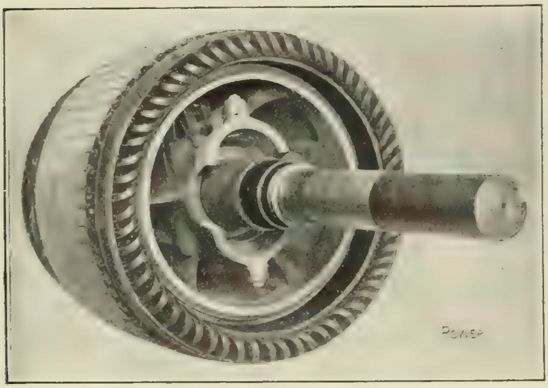


FIG. 67. GOVERNOR EMPLOYED ON LARGE MOTOR

The repulsion motor, as described in Part 6, has series characteristics, that is, a variation through wide ranges of speed and torque from no load to full load. To overcome this, it is necessary to short-circuit the armature after the motor has come up to speed, thus converting the machine into one that has squirrel-cage characteristics or practically a constant speed from no load to full load.

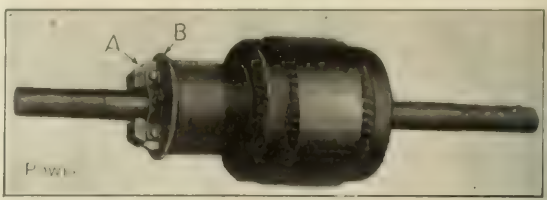


FIG. 68. ROTOR OF BELL MOTOR

By the addition of another set of brushes, *cd* Fig. 69, set 90 electrical degrees from the first set, the motor can be made to operate at practically constant speed, and the short-circuiting device can be dispensed with. Brushes *ab* are known as the energy brushes, and brushes *cd* as compensating brushes, and when both sets are in use there will be a resultant torque due to their combined action. With the brushes in the position shown, the action of brushes *ab* will be much greater than brushes *cd* and the direction of rotation will be as determined by the brushes *ab;* that is, the direction in which they are shifted with reference to the axis of the field poles. The no-load speed of this motor will be slightly above synchronism while the full-load speed will be below.

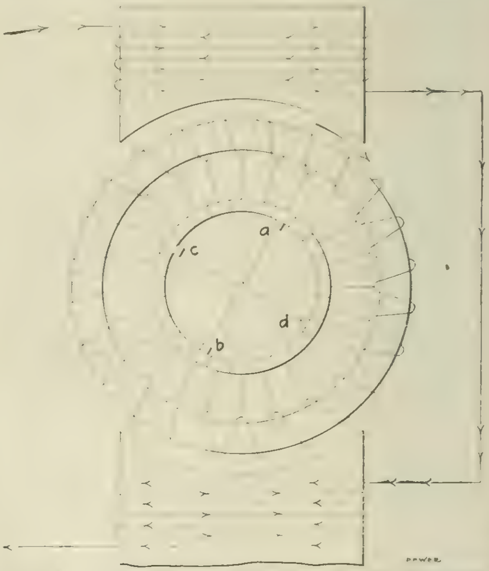


FIG. 69. ILLUSTRATING CONSTANT-SPEED FEATURES

By the addition of another winding concentric with the center portion of the main stator winding and connected with the compensating brushes *cd,* as shown diagrammatically in Fig. 70, the power factor may be increased to unity or above, which is a distinct advantage over the other types of induction motors, the power factor of which under the best conditions is usually never above 85 per cent.

The General Electric Co. builds a single-phase compensated repulsion induction motor of the same type as just described. The stator winding is shown in Fig. 56, Part 6. The compensating winding is auxiliary to the main stator winding and forms the center portion of the field-pole windings. Fig. 71 shows the armature used in this motor; the winding on the armature is of the series type connected to a horizontal commutator. A fan is mounted on the back end of the armature to improve the ventilation. When started, if this motor is connected directly to the line, it will develop 250 per cent. of full-load torque, and if started with a rheostat will develop full-load starting torque on about 200 per cent. of full-load current. To reverse the direction of rotation, shift the brushes to the opposite side of the stator field axis and interchange the compensating leads connected to the brushes. If the brushes are shifted and the leads of the compensating winding are not interchanged, the motor will emit a humming sound, develop a low starting torque and take an abnormally heavy current from the line, which will cause excessive heating of the field winding.

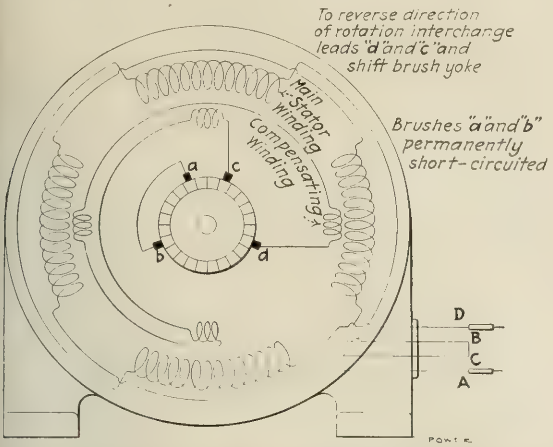

To reverse direction of rotation interchange leads "d" and "c" and shift brush yoke
Main Stator Winding
Compensating Winding
Brushes "a" and "b" permanently short-circuited
a
c
b
d
D
B
C
A
POWER

FIG. 70. WIRING DIAGRAM OF CONSTANT-SPEED MOTOR

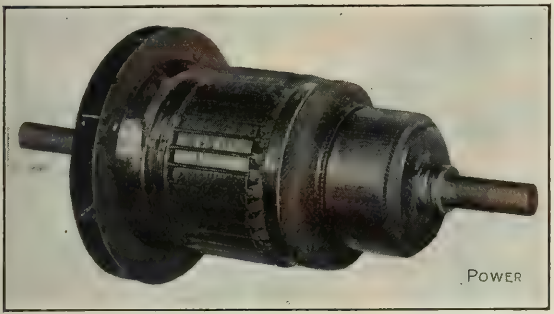


FIG. 71. COMMUTATOR END OF ARMATURE

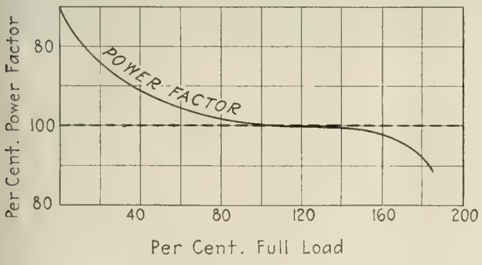


FIG. 72. VARIATION OF POWER FACTOR WITH LOAD

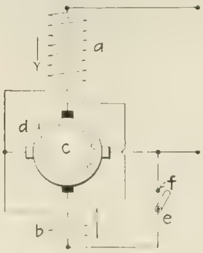


FIG. 73. DIAGRAM OF WINDING

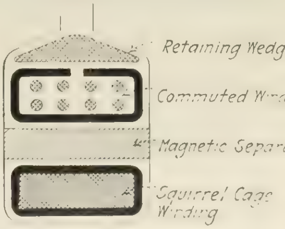


FIG. 74. ONE SLOT OF ROTOR, SHOWING CONSTRUCTION

A few years ago the Wagner Electric Manufacturing Co. brought out a new type of alternating-current compensated motor known as the unity power factor single-phase motor. This motor has approximately unity power factor at full load and a leading power factor at loads between full load and no load, decreasing to 60 per cent. leading at no load (see Fig. 72). However, this leading power factor can be used in most cases to compensate the lagging power factor of the generating plant and distribution system, thereby increasing the capacity of the plant and the line.

The construction of this motor is similar to the compensated motor previously described; the electrical connections are shown in Fig. 73. The stator winding has a main winding *a* and a compensating winding *b*. The chief departure is in the armature in which two windings are also used; the principal winding *c* is of the usual squirrel-cage type and occupies the bottom of the armature slots; auxiliary winding *d* occupies the upper part of the slots, is similar to that used in the machine previously described and is connected to a horizontal commutator. Between the two windings is a magnetic separator made of a soft rolled steel bar. Two sets of brushes are provided, the main pair of brushes (shown solid) is placed on the axis of the main stator winding, and is short-circuited, thus giving the repulsion-motor characteristics; the auxiliary pair is placed at right angles to the axis of the main stator winding and is connected in series with it. A cross-section of an armature slot is represented in Fig. 74.

During starting, switch *f*, Fig. 73, is open, and the compensating winding carries no current. The commutated winding *d* is in series with the main stator winding *a*. The commutated winding develops the torque at starting, and as the motor increases in speed the torque in this winding decreases very rapidly, but is more than offset by the torque developed in the squirrel-cage winding, which increases very rapidly, reaching a maximum at about 4 or 5 per cent. slip where it starts to decrease and becomes zero at synchronism. Above synchronous speed the torque in the squirrel-cage winding is reversed and it acts as a brake and balances the torque due to the series repulsion winding. The squirrel-cage winding, therefore, effectually prevents the motor from racing at light loads and gives it practically a constant speed between no load and full load. The torque developed by the squirrel-cage winding is zero at starting, but increases very rapidly beyond a certain speed, which has the effect of giving the motor a speed torque which increases with the speed and insures the motor pulling through any load that it can start.

The magnetic separator acts as a shunt for the flux set up by the main stator winding at starting, and at the same time causes the inductance of the squirrel-cage winding to be high; consequently, the current set up in this winding is small at starting. As the motor speeds up this magnetic shunt effect is decreased by the action of the current in the squirrel-cage winding, and when near synchronous speed the machine operates practically in the same manner as if the magnetic separator did not exist at all. When the motor has reached nearly synchronous speed a small centrifugal switch *e*, located on the outer end of the armature shaft, is closed; this connects the auxiliary winding across the series brushes. This winding controls the power factor of the motor.

⁂

Progress of Panama-Pacific Exposition

The progress made in the construction of the Panama-Pacific International Exposition is clearly shown in the accompanying panoramic photograph taken from the roof of the completed Palace of Machinery, the largest wooden building ever erected.

A Panoramic View of the Panama-Pacific Grou

The exceptional beauty of the site, fronting as it does for three miles on the bay of San Francisco within a stone's throw of the portals of the far-famed Golden Gate and with the evergreen hills of Marin on the opposite shore, is apparent.

In the background can be seen the Presidio, San Francisco's great army post, and to the extreme left, part of the residence district of the city. To the right is the Palace of Mines and Metallurgy, which is 60 per cent. complete; adjoining it on the left is the Palace of Varied Industries, also 60 per cent. complete. To the rear of these may be seen the Palace of Transportation, 50 per cent. complete, and behind that the Palace of Agriculture, 65 per cent. complete.

The building with the dome in the rear center is the Palace of Education, which is 90 per cent. complete, and in the fore of that the Palace of Liberal Arts, which is 60 per cent. complete. To the left and a bit forward is the Palace of Manufacture, 55 per cent. complete, and the site of the great Court of the Sun and Stars.

The rapidity of the progress made may be realized when it is understood that the first ground was broken for the palaces on Jan. 1, 1913.

⁂

Opening of the 201st St. Station, New York

New York's latest big power station was offcially placed in commission Jan. 31. It is the new generating station of the United Electric Light & Power Co., located at West 201st St and the Harlem River. The purpose of the station is to supply the growing upper section of the city, and so it has been built to allow of additional equipment as the need arrives. At present it contains three 15,000-kw. turbo-generator units and has space for five more like them so that the building as it now stands represents a possible capacity of 120,000 kw. Reserve space is available in the same way for boilers, electrical wiring and equipment and panels on the switch and control boards for corresponding accessions of capacity.

In addition to the numerous individual invited guests, the opening ceremonies were witnessed by parties from the Brooklyn Engineers' Club and the Municipal Engineers of New York. The visitors, as they arrived at the Dyckman St. station of the subway were met by automobile busses and taken directly to the plant. There guides were appointed to take them by groups for an inspection of the plant. About 12:30 all congregated on the main floor to see the first unit started.

Luncheon was then served on the seventh floor of the building where addresses of welcome and brief histories of the enterprise were given by Frank W. Smith, vice-president of the United Electric Light & Power Co., and George B. Cortelyou, president of the Consolidated Gas Co., and one of the directors of the United company.

The building is fireproof, being of brick, steel and concrete throughout. It is seven stories high in the main part, although the equivalent height in the boiler section is divided into only two tiers. Above the boiler house is a 15,000-ton coal storage. The whole structure is 330x200 ft., and contains 200,000 sq.ft. of floor area. The four chimneys are each 22 ft. in diameter and 325 ft. high. On the several floors in the electrical-gallery section are the offices, busbar switches and reactance coils, busbar compartments, selector oil switches and feeder and generator switches.

All operations are directed from a control gallery on the second floor containing the generator benchboard and the semi-circular feeder-control boards, from which all switches are controlled. On the first floor is a storage battery and the generator rheostats.

On the street level (the basement) are the exciter-control board, exciters and transmission transformers. The 200-kw. exciters are directly connected to 7500-volt induction motors. The main turbine room is on the first-floor level, and beneath it is the auxiliary apparatus. All the steam auxiliaries are turbine-driven and the ventilating fans are motor driven.

On the first-floor level of the boiler house are thirty-two 650-hp. water-tube boilers, and space for an equal number is reserved on the second-floor level. Coal is delivered from the elevated bunkers to the automatic stokers that minimize the smoke by insuring practically perfect combustion, and the cinders are eliminated from the gases by furnace-gas cleaners.

From pockets under the boiler, ashes are transferred to cars hauled by electric mine locomotives and dumped into a hopper which feeds a skip hoist. This conveys them over the street to a hopper in a coal tower from which they are discharged into boats or carts. The coal tower is 240 ft. high and on the bulkhead at the water's edge to hoist coal as received on boats or barges and dump it into a hopper. From thence it passes through a crusher and into coal cars in which it is weighed. These cars are cable-hauled to the main building and dumped into the storage bunkers.

Conference of American Electric Railway Association

The midyear meeting of the American Electric Railway Association was held in New York on Jan. 29, 30 and 31. The first and third days were given up to committee meetings and on the evening of the 29th a banquet was held at the Waldorf-Astoria, about 800 attending.

Addresses were delivered by Charles N. Black, president of the association; C. S. Hawley, president of the American Electric Railway Manufacturers' Association; Guy E. Tripp, chairman of the board of directors, Westinghouse Electric & Manufacturing Co., and H. W. Anderson, vice-president and general counsel, Virginia Railway & Power Co. President Black decried the present system of public service supervision and announced that $100,000 was to be raised by the association to be devoted to a publicity campaign to counteract the popular demand for public utility regulation.

Sowing the Progress Made in Building Erection

The general conference took place on Jan. 30, five papers being presented. Martin Schreiber discussed the value of the company sections and this was followed by a report of the special committee on the joint use of poles.

"The Economic Aspects of Regulation Compared with Profit Sharing with Municipalities" was the title of a paper by Halford Erickson, of the Wisconsin Railroad Commission. This discussed local versus state supervision and regulation, and also pointed out that one of the duties of a public service commission was to protect the public utilities' interests as well as the public's, for upon the former indirectly depended the ultimate service to the public. The other subjects discussed at the conference were "The Effect of Rate of Fare on Riding Habit," by F. W. Hild, L. R. Nash and S. G. McMeen, and "Influence of Labor on Legislation," by C. L. S. Tingley.

Civil-Service Opportunities

COMPETITIVE EXAMINATIONS *for the civil-service positions named below will be held on the dates given. Applications and further information maybe had by addressing the respective commissions. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.*

Assistant Steam Engineer—State and County Hospitals, Departments and Institutions. The New York State Civil Service Commission will hold an examination for this position, Feb. 21, 1914. Usual salaries $480 to $900 with maintenance when employed in institutions. Candidates, unless technical graduates, must have had two years' experience as machinists, boilermakers, steamfitters, oilers, firemen, engineers or electricians, including at least one year in the operation of steam engines or electrical machinery, which latter is also required of technical graduates also. Subjects of examination: Practical and technical questions on the operation and repair of steam engines, boilers, steam-heating apparatus and electrical machinery. Application blanks must be obtained by Feb. 11 and returned before Feb. 13. Address State Civil Service Commission, Albany, N. Y.

Diesel Engine Exhibit at Panama-Pacific Exposition

It is announced by the department of machinery of the Panama-Pacific International Exposition that since Jan. 1, more than 30,000 sq.ft. of exhibit space has been contracted for in the Palace of Machinery. More than a dozen firms have contracted for space in which to install engines built on the Diesel principle. These will occupy a central space in the Palace of Machinery, and will be under operation through connection with electric generators or other machinery to show the economy of working.

A large amount of exhibit space has also been spoken for by the manufacturers of steam turbines and unit type plants. In the electrical department there will be demonstrated the latest apparatus for the transmission and control of electric currents at high voltage.

* * *

New Federal Power Plant—Plans are now being drawn for a central power, light and heating plant in Washington to serve the group of Government buildings, including and adjacent to the White House and those on the opposite side of the Mall. The new plant will be located in the southwest section of the city, on the Potomac, and will probably have a capacity of about 6000 hp. Steam turbines will be employed and will run partly condensing (depending upon the heating demand), the exhaust being used for supplying steam and hot water to heat the buildings. L. B. Stillwell & Co., of New York, will do the engineering work.

SOCIETY NOTES

The 35th annual entertainment and ball of Jersey City Association No. 1, N. A. S. E., was held on Friday evening, Jan. 30, at Elks Hall, Jersey City, N. J.

The Engineers Society of Western Pennsylvania elected the following officers Jan. 20: President, Albert R. Raymer; vice-president, Samuel E. Duff; treasurer, A. E. Frost; directors, George K. Neilson and Fred Crabtree. The membership is now 1124.

The Combined Associations, N. A. S. E., of Philadelphia, held their fifth annual entertainment and banquet at Lulu Temple, on Wednesday evening, Jan. 28. In the combined associations are Quaker City No. 1, Tacony No. 9, Merrick No. 12, and Northeast No. 20. A clever entertainment was given by national and local professional talent.

On Tuesday evening, Feb. 10, at 8.15 p.m., S. W. Dudley, assistant chief engineer of the Westinghouse Air Brake Co., will present a paper on "Brake Performance on Modern Steam Railroad Passenger Trains," at the meeting of the American Society of Mechanical Engineers, Engineering Societies Building, New York City. The data given are the result of tests made by the Pennsylvania R.R. in conjunction with the Westinghouse Air Brake Co. An informal dinner will be served at 6.30 p.m.

PERSONALS

John Beattie, formerly with the Consolidated Gas, Electric Light & Power Co., Baltimore, Md., is now chief engineer of the Metropolitan Life Insurance Co.'s Sanatorium, Wilton, N. Y.

Prof. J. Ansel Brooks will conduct the Brown University course in industrial organization and management. Prof. Brooks has been a member of the Brown faculty since 1903, and has been associate professor of mechanics and mechanical drawing since 1909. He was instructor in mechanical engineering at Yale from 1897 to 1901. His degrees are Ph. B., Yale, 1897, and M. E., Yale, 1901. He is a member of the American Society of Mechanical Engineers, the Society for the Promotion of Engineering Education and the American Society for the Advancement of Science.

A. Reiche, formerly general manager of the Orenstein-Arthur Koppel Co., Koppel, Penn., sailed for Germany recently and has been succeeded by Erich Joseph, formerly the company's New York manager. Mr. Reiche has served for many years in the above capacity and under his supervision the plant has been greatly increased, with numerous branch offices in this country and in the West Indies. Mr. Reiche will assume the position of managing director for a large German manufacturer of locomobiles and agricultural machinery. Mr. Joseph has also been connected with the Orenstein-Arthur Koppel Co. for many years.

Prof. John Edson Sweet, the "Grand Old Man" of Syracuse engineering circles, was given the degree of doctor of engineering at the midwinter meeting of the board of trustees of Syracuse University. Prof. Sweet, who is president of the Straight Line Engine Co., was born in Pompey on Oct. 21, 1832. After a career in England he was professor of engineering at Cornell University. He is widely known throughout the country for his numerous inventions, among which are the oil ring in universal use for lubricating bearings, the matrix compositor, which was the first step toward the linotype machine, the Sweet ingot mold, governor and a measuring machine. He was one of the founders of the American Society of Mechanical Engineers and its third president. He is a charter member of the Technology Club and was its first president.

Joseph N. Gregory, for the last eight years Western New York manager of the Dearborn Chemical Co., is suggested by the Commissioner of Public Works for the new position of mechanical engineer in the Bureau of Buildings, Buffalo, N. Y. Mr. Gregory is an efficiency engineer, has a wide reputation, and is considered an expert in all matters allied with engineering problems.

Mr. Gregory was formerly president of the Marine Engineers' Association, New York branch, and has been president of the local body of the National Association of Stationary Engineers. At the time he assumed his present position he was vice-president of the State Association of Stationary Engineers. He is a member of the American Society of Mechanical Engineers, the American Railway Club, the Canadian Railway Club and various other mechanical and engineering societies throughout the country. For some time he was a member of the Civil Service Commission under Mayor Conrad Diehl of Buffalo. He is at present a member of the executive committee of the Board of Trustees of Locals 16 and 40 of the National Association of Stationary Engineers.

OBITUARY

WILLIAM COOPER

William Cooper, director of buildings and equipment at the Westinghouse Electric & Manufacturing Co., died Jan. 23. He was graduated from Cornell University in 1887 and became chief engineer of the Twin City Rapid Transit Co., St. Paul, Minn. Later Mr. Cooper was in the engineering department of the General Electric Co., at Schenectady. For six years he was chief engineer at the Bullock Electric & Manufacturing Co., at Cincinnati, leaving there to join the Westinghouse forces.

GEORGE J. WEBER

George J. Weber, inventor of a gasoline engine and former president of the Weber Gas & Gasoline Co., died recently at his home in Kansas City. Mr. Weber had more than forty patents granted to him covering nearly every phase of gas and gasoline engine construction. The turbine engine with which he was experimenting at the time of his injury will be completed by his sons.

He is survived by his wife, Mrs. Mary Louise Weber, and by four children, Edwin W., Lloyd H., Miss Cora Weber and Robert G. Weber, of New York.

JOHN C. KELLEY

John C. Kelley the founder and only president of the National Meter Co. for the past 44 years, died at his home, 247 Hancock St., Brooklyn, Jan. 24.

Mr. Kelley was born in Woodford, County Galway, Ireland, on Apr. 17, 1839. He came to this country with his parents when eight years old. His boyhood days were spent at Rochester and Palmyra, N. Y. From there his parents moved to Franklin, Ohio, and later to Cincinnati, where he was engaged in the retail dry-goods trade. On Jan. 1, 1860, he came to New York and entered into partnership with his uncle, the late Austin Kelley, in the manufacture of hoop skirts. On Sept. 9, 1860, he married Carrie A. Stuart, of New York.

Through an accident, Mr. Kelley met a man with a patent water meter, and on Jan. 5, 1870, he organized the National Meter Co., which he built up to a large and successful organization.

Mr. Kelley was prominent in the civic life of Brooklyn, and was identified with Loyola Union, Catholic Benevolent Legion, the Emerald Association, and many other organizations. During the first term of Mayor Low he was appointed to the old Brooklyn Board of Education.

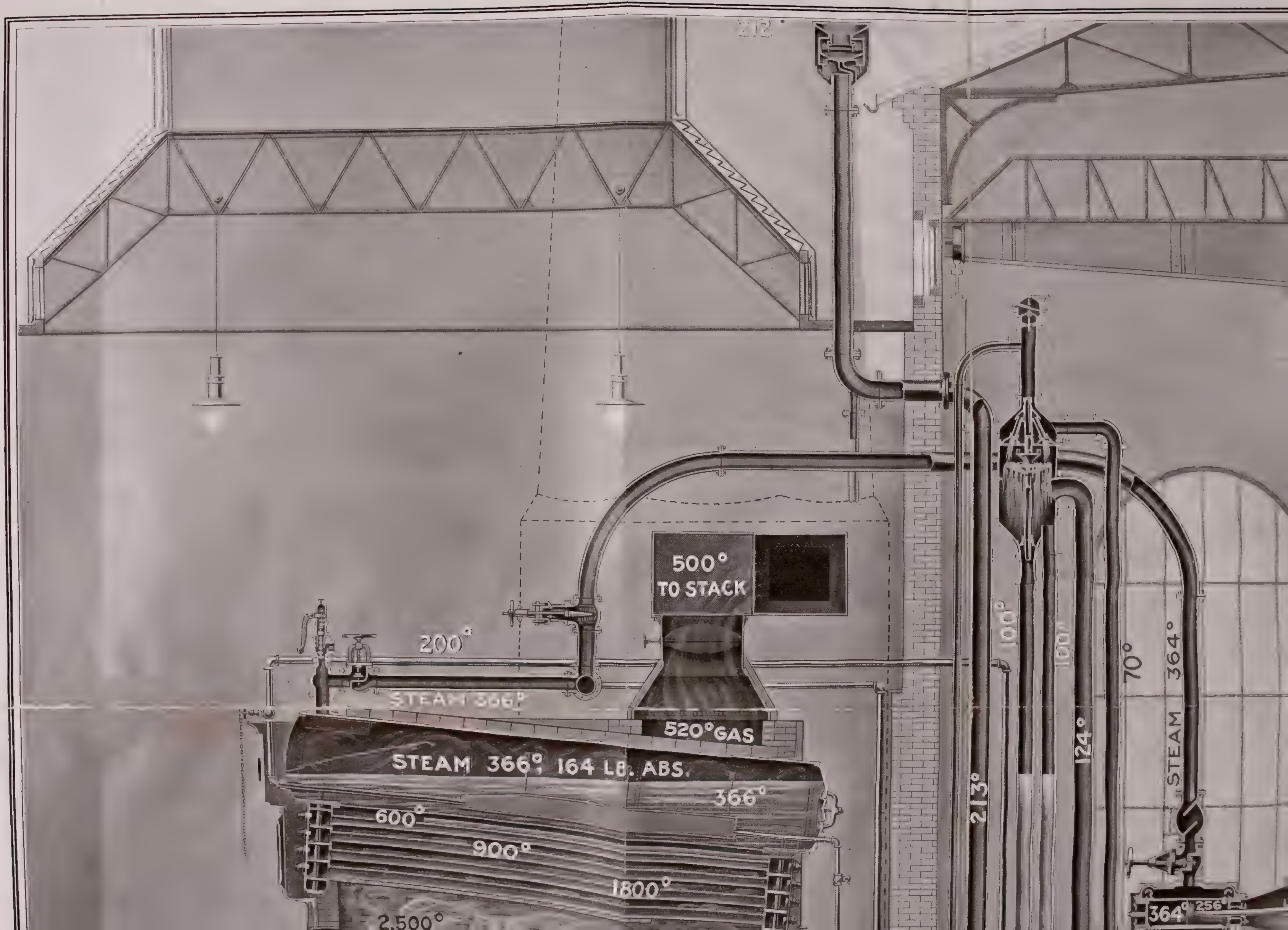
He was one of the charter members of the American Water Works Association. Among his friends who knew him well, he was known as a man of sterling integrity, remarkable firmness of character, and the tenderest sympathy for anyone in trouble. On account of his failing health Mr. Kelley withdrew from all outside organizations except the Home Trust Co., of which he was a director at the time of his death. He is survived by his widow, five daughters and two sons.

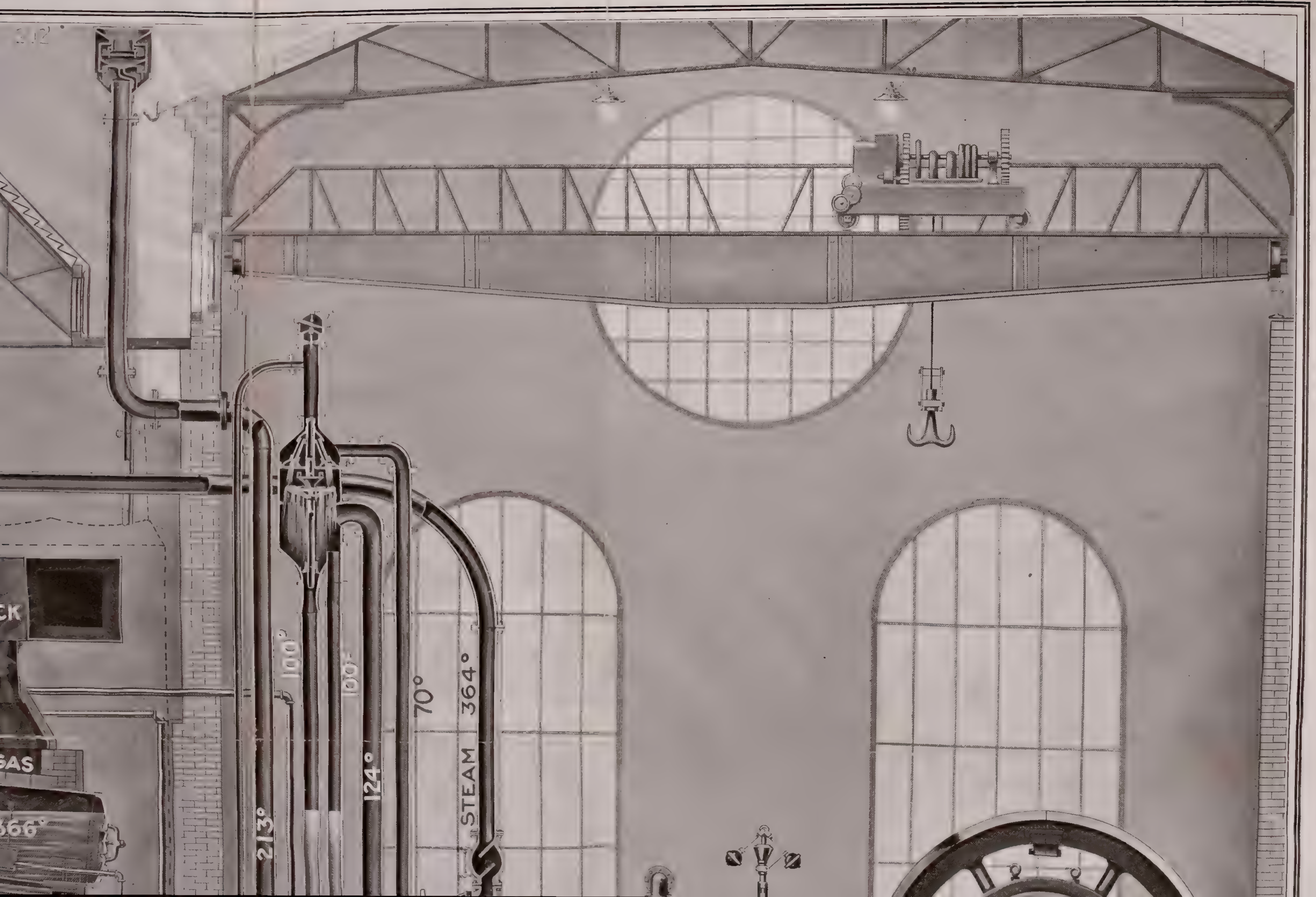
⁂

Novel Liquid Meter—The Leinert liquid meter automatically measures water, petroleum, sugar juice and other liquids, the measurements being made by weight and not by volume, therefore the temperature does not enter in. The meter has a pair of equal-sized tanks so arranged that when one is filled to standard level it automatically shifts the feed over to the second tank and is then emptied by siphon, recording at each time of filling and emptying. As this meter is actuated by the weight of the liquid, it is not subjected to the sudden inaccuracies of volume meters, and has scarcely any wearing parts. It can also be quickly cleaned and sterilized.—"Scientific American."

⁂

To Stimulate Internal-Combustion Turbine Development—It is proposed that England's Royal Automobile Club offer a prize for the most practical rotary or turbine oil or alcohol engine applied to a motor vehicle and entered for trial under the club's regulations in 1915. The amount of the prize has not been stated.


212°
200°
STEAM 366°
500° TO STACK
520° GAS
STEAM 366°, 164 LB. ABS.
366°
600°
900°
1800°
2,500°
213°
100°
100°
124°
70°
STEAM 364°
364°
256°


212
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366°
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100°
100°
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70°
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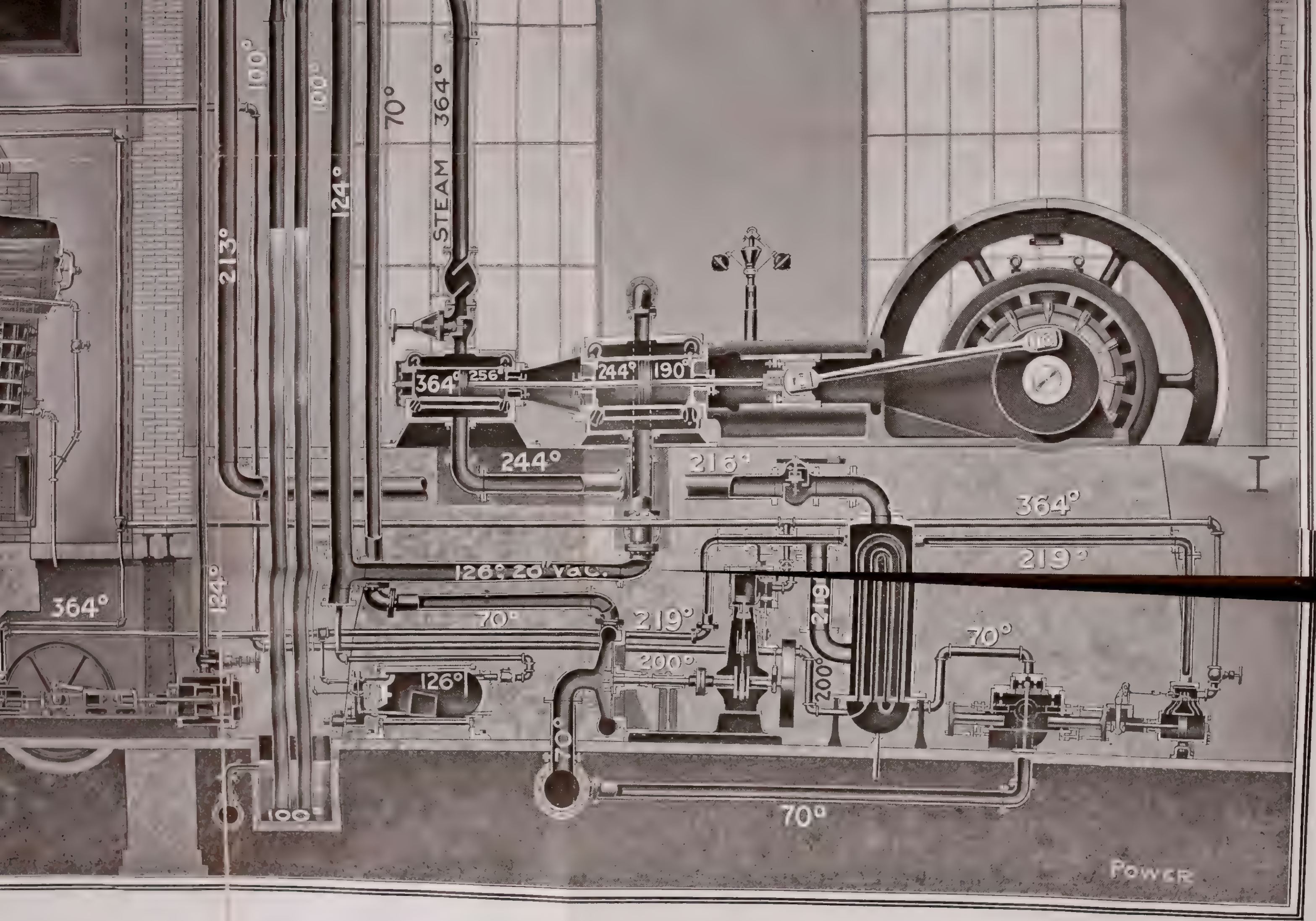
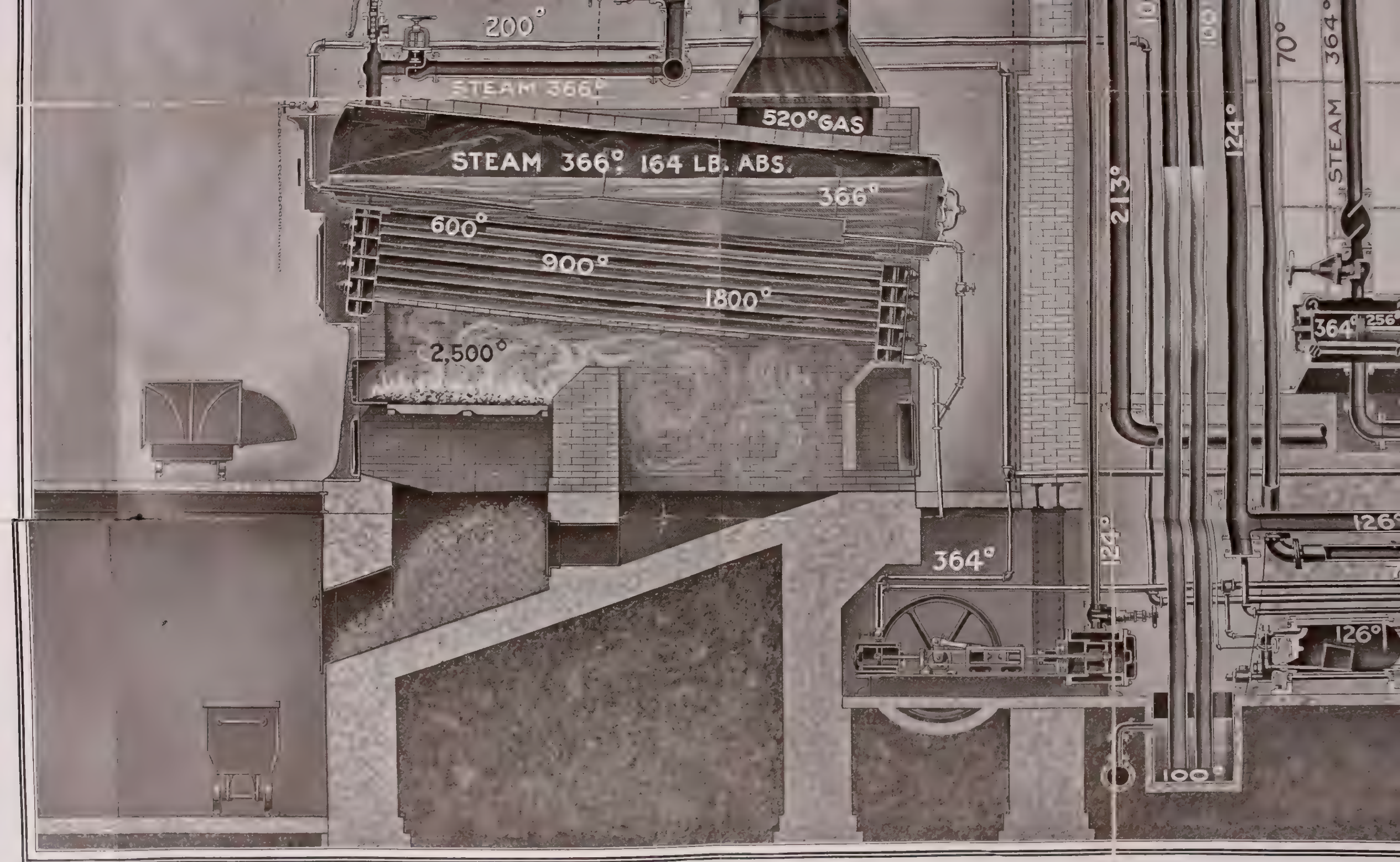
STEAM



erating Condensing, Showing the Variation of Temperature and Pressure of the Boiler Gases and of the Steam During the Course from the Boiler Through the Engine, Condenser and Back to the Boiler.



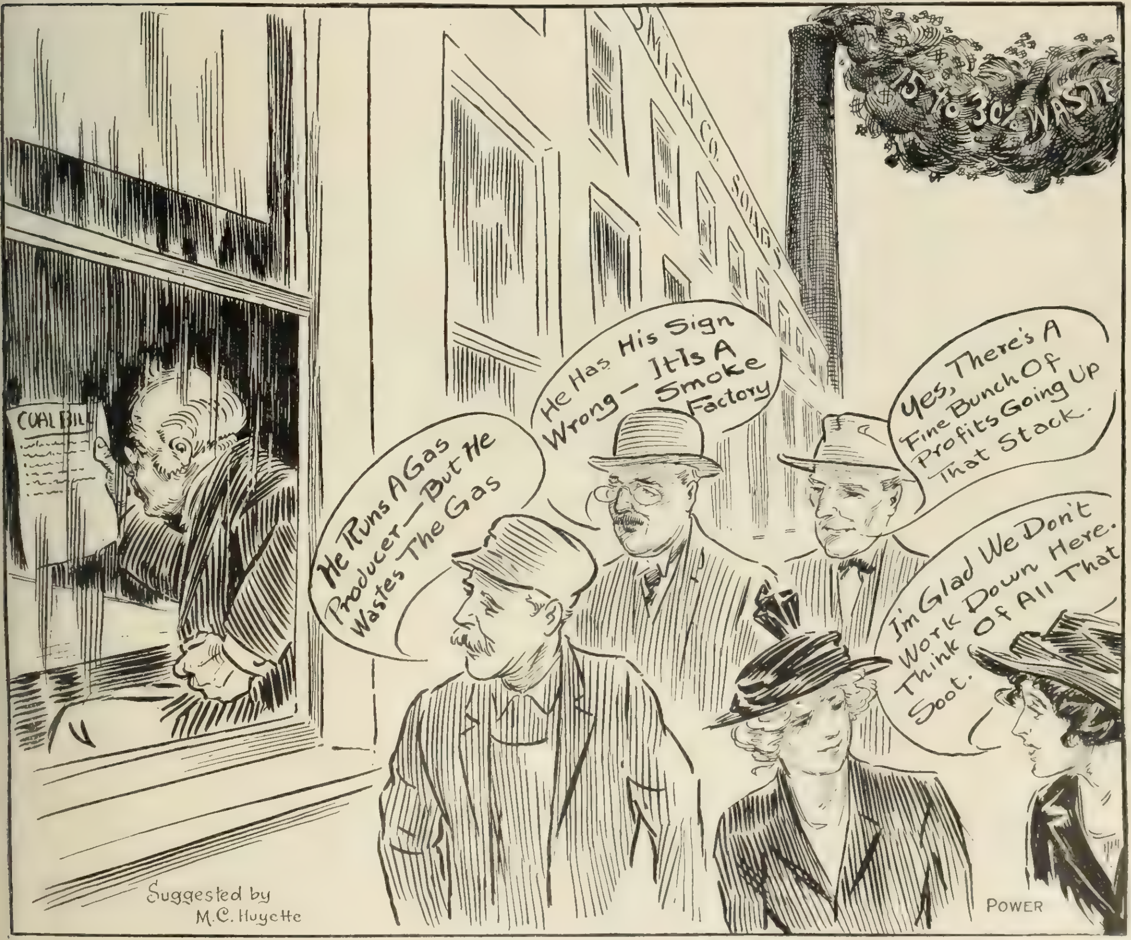
Supplement to Power February 17th 1914. Vol. 39, No. 7.

Sectional View of the Apparatus and Piping of a Typical Reciprocating Engine Plant, Operating Condensing, Showing the Variation of Temperatur
Through the Engine, Condenser and Back to the Boiler.

POWER

Vol. 39 NEW YORK, FEBRUARY 17, 1914 No. 7

Smoke Means Waste


COAL BILL
SMITH CO. SOAPS
15 to 30% WASTE
He Runs A Gas Producer—But He Wastes The Gas
He Has His Sign Wrong— It's A Smoke Factory
Yes, There's A Fine Bunch Of Profits Going Up That Stack.
I'm Glad We Don't Work Down Here. Think Of All That Soot.
Suggested by M.C. Huyette
POWER

APPARENT TO ALL BUT THE ONE MOST CONCERNED

The Lardner's Point Pumping Plant

By Warren O. Rogers

SYNOPSIS—Philadelphia, in 1801, built the first water-works system in the United States at a cost of $220,360. This city has the distinction of operating the largest pumping water-works plant in the world. The latest distributing station is the Lardner's Point plant, with a normal capacity of 240,000,000 gal. of water per 24 hr. There are twelve 20,000,000-gal. vertical triple-expansion pumps in two stations, supplied with steam by fourteen 500-hp. water-tube boilers.

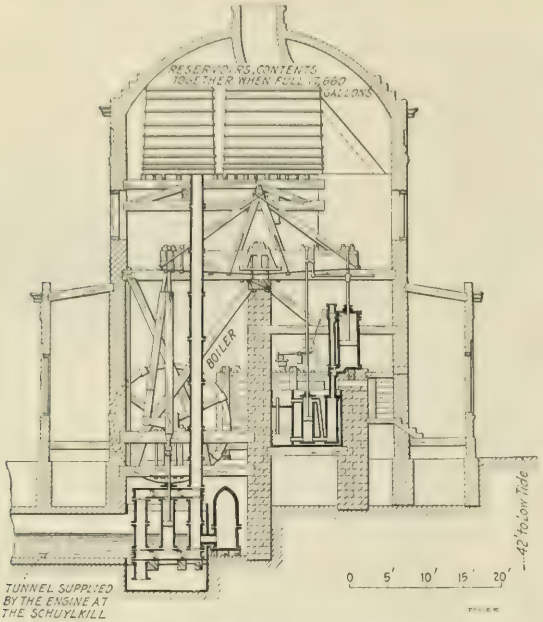

RESERVOIRS, CONTENTS TOGETHER WHEN FULL 17,660 GALLONS
BOILER
42' to LOW Tide
0 5' 10' 15' 20'
TUNNEL SUPPLIED BY THE ENGINE AT THE SCHUYLKILL

FIG. 1. OLD CENTER SQUARE PUMPING PLANT

The city of Philadelphia enjoys the distinction of having operated the first steam-pumped water system in the United States and also of operating the largest pumping plant in the world. There are two rivers from which to draw the water, the Schuylkill and Delaware, the latter river furnishing at present approximately 70 per cent. of the city's water consumption.

The first pumping engine used had a capacity of 962,520 gal. of water per 24 hr. with a consumption of 55 bu. of coal. The Lardner's point pumping plant consists of two separate stations, with twelve 20,000,000-gal. pumps of modern design for high-service work.

The old Center Square pumping-plant building, a section of which is shown in Fig. 1, was constructed of marble and was 60 ft. square at the bottom and 25 ft. high. The upper part was built in circular form, having a diameter of 40 ft. and being 60 ft. high. It was surmounted by a dome through the center of which the stack from the boiler extended.

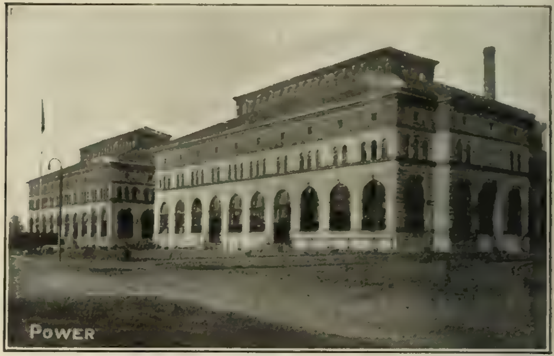


FIG. 3. FRONT VIEW OF LARDNER'S POINT STATION

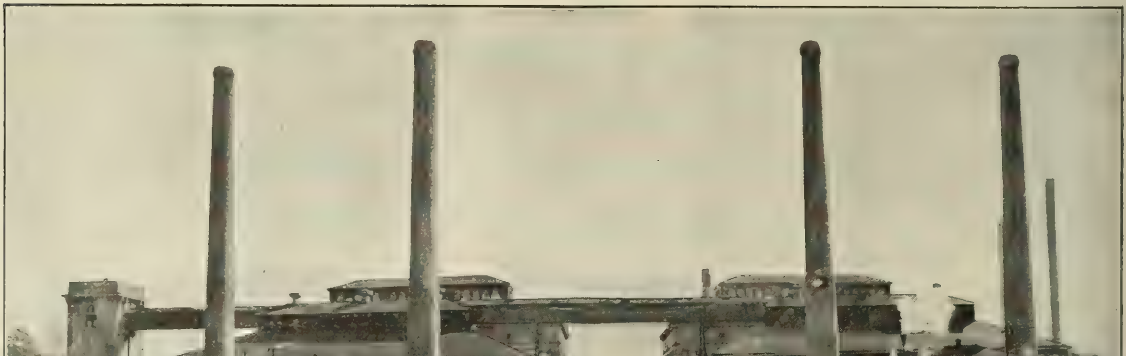


FIG. 2. BOILER-HOUSE SIDE OF PUMPING STATION

When one considers the material of which the pumping engine and boiler was constructed, it is a matter of surprise that the apparatus had such a large capacity. For instance, all the levers, beams, flywheel, shafts and arms, cold-water pumps and cisterns were made of wood. Even the boiler was a $^5/_7$-in. white-pine box, 9 ft. high, 9 ft. wide and 15 ft. long, securely bolted through and braced on the outside. The boiler firebox was of wrought iron with cast-iron vertical flues. The main cylinder of the engine was cast in two pieces, united with copper, the joints being secured externally by a cast-iron band. Nearly four months were consumed in boring the cylinder. The force pumps were double-acting and were first used without air chambers.

The engine pumped water into two wooden tanks on top of the buidling, which were 50 ft. above the bottom of the brick tunnel leading from the Schuylkill pumping house, where a similar pump was in operation. These tanks held 17,094 gal. The engine was able to fill them in about 25 min., the same time being taken to exhaust them. Any disability of the pump meant a water famine in a few minutes.

The present pumping system of the city comprises four high-duty stations, three of which are on the Schuylkill River, and the other at Lardner's Point. The latter connects with the Torresdale conduit and pumps Delaware River water after it has passed through the filters at Torresdale. A description of the Torresdale plant and filter beds was published in Power, Nov. 16, 1909, page 811. This plant contains seven 40,000,000-gal. centrifugal pumps and one 50,000,000-gal. unit, the water being pumped to the preliminary filtering beds and flowing by gravity to the final filters.

After the water has passed through the final filters it flows by gravity to a filtered water basin having a capacity of 50,000,000 gal. This filtered water is carried to the Lardner's Point pumping station through a conduit 13,807 ft. long and 10 ft. 7 in. in diameter. The conduit has an elevation at the entrance shaft of 127 ft. below the ground surface, but at the outlet end is 10 ft. higher, the rising grade being made to prevent air pockets.

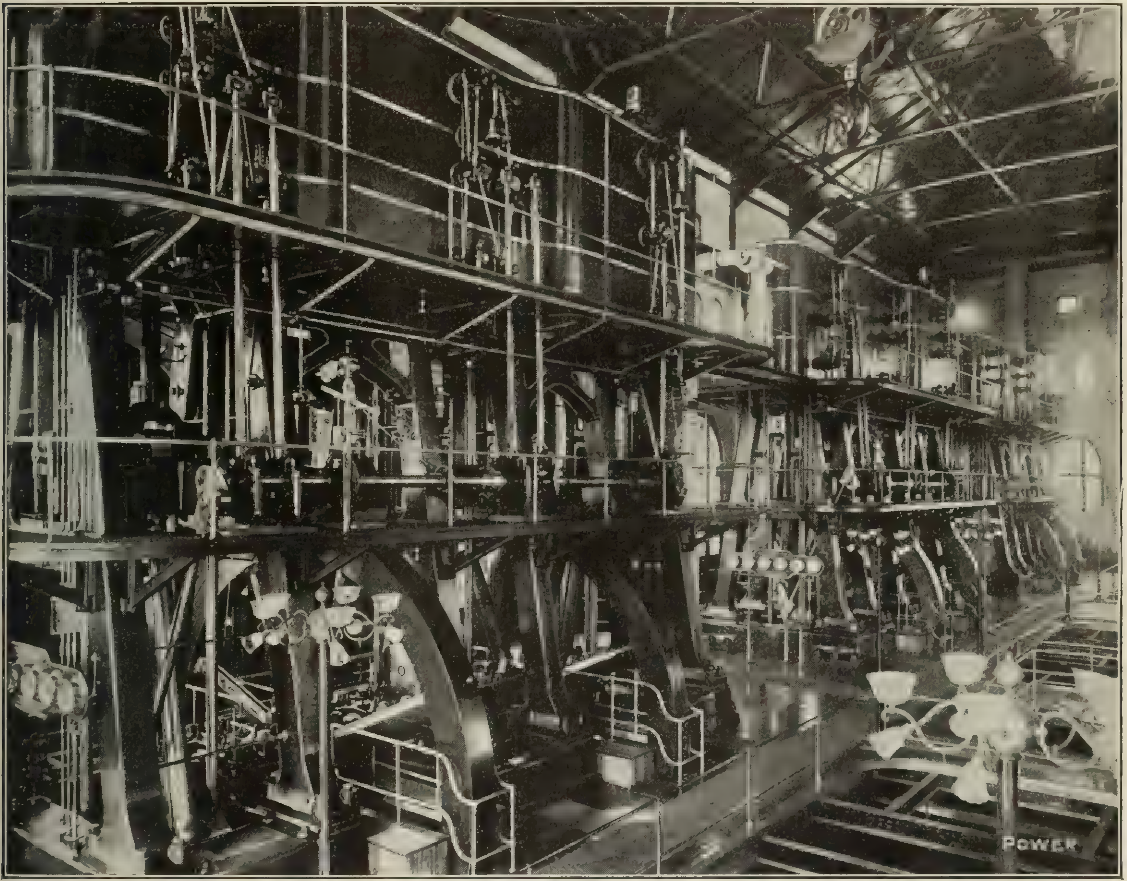


Fig. 4. Partial View of Pumping Engines in No. 2 Pumping Station

The pumping outfit at Lardner's Point consists of two plants, known as Nos. 2 and 3 stations. Rear and front views of the buildings are shown in Figs. 2 and 3, each building containing six vertical, triple-expansion pumping engines, each of 20,000,000-gal. capacity.

An interior view of each plant is shown in Figs. 4 and 5. The engine rooms are built separately from the two boiler houses and are 171 ft. long by 87 ft. wide and constructed of gray brick with granite and terra cotta trimmings. The roof coverings are of red tile.

The water ends of the pumps are in the basement, Fig. 6, under the floor of the engine room; the entire steam ends are above the floor level. The pump well is placed under the basement floor in the center of the building and extends the full length, being horseshoe-shaped in sections, 11 ft. in width, and constructed of reinforced concrete. Data relating to the engines in the two stations are as follows:

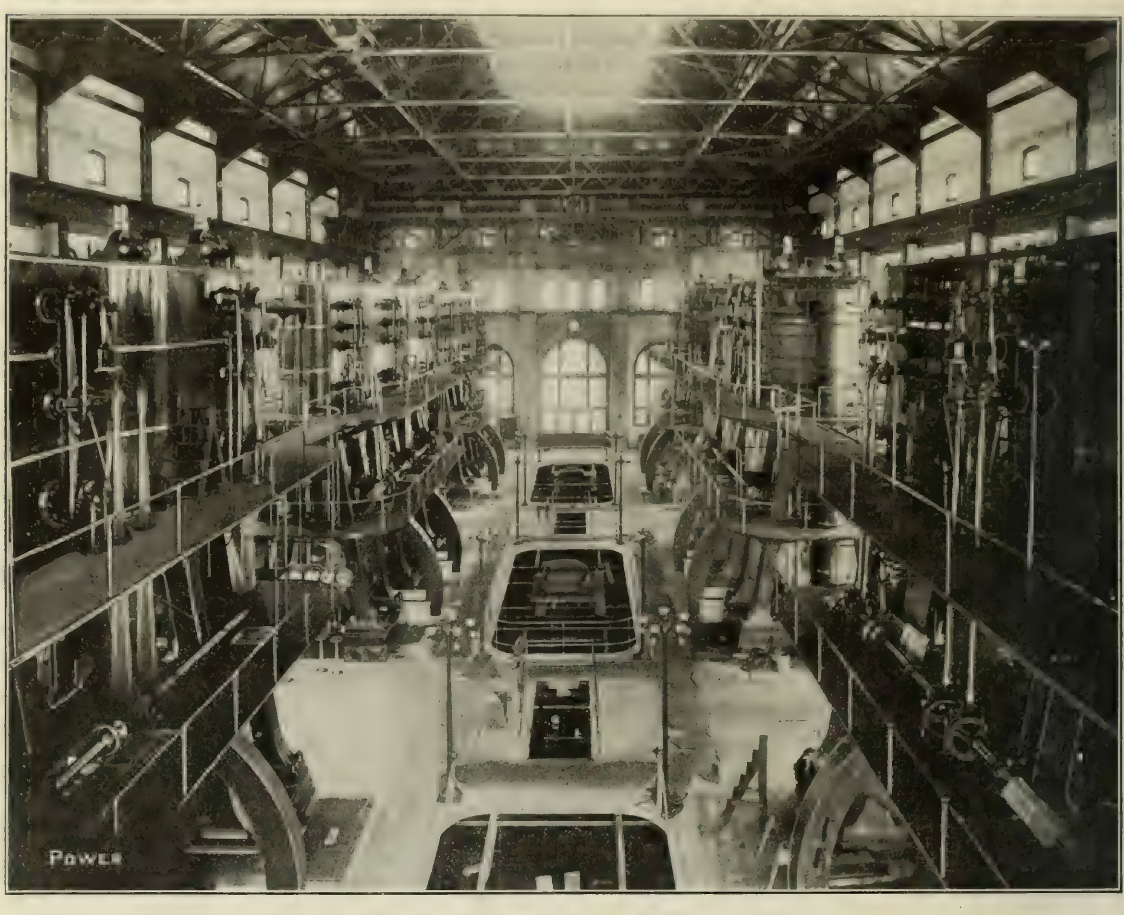


FIG. 5. PUMPING ENGINES IN NO. 3 PUMPING STATION

Nominal capacity of each engine, gal. daily.	20,000,000
Number of r.p.m.	20
Stroke, ft.	5½
Piston speed, ft. per min.	220

	High	Intermediate	Low
Cylinder diameter	32″	60″	90″
Diameter piston rod	7½″	7½″	7½″

	First	Second
Receiver volume	205 cu.ft.	304 cu.ft.
Receiver heating surface	166 sq.ft.	304 sq.ft.

	Diameter	Length
Crosshead pins	12″	11″
Crank pins	12″	11″
Shaft bearings	17½″	32″
Shaft at center	20¼″	

Distance rods—Four, each 5-in. diameter.
Air pump—One 28-in. diameter, 66-in. stroke.
Feed pump—One 3¼-in. diameter, 66-in. stroke.
Feed water heater—One in exhaust, 308 sq.ft.
Flywheels—Two, 20-ft. diameter and weighing 32 tons each (approximate).
Throttle valve—8in. diameter.
Exhaust pipe—24⅜-in. diameter.
Suction pipe—Main 42-in. diameter, branch 30-in. diameter.
Discharge pipe—Main 42-in. diameter, branch 30-in. diameter.
Suction injection—8-in. and 10-in. diameter.
Force injection—3-in. and 3½-in. diameter.
Overflow—18-in. diameter.
Diameter of plungers—33 in.

	No. 2 House	No. 3 House
Number of pump valves	960	864

Each pump is fitted with a feed-water pump, a heater and an ejector condenser, one of the condensers being shown in Fig. 6. Water for condensing purposes, taken from the Delaware River, is returned to the river after passing through the condensers. The condenser air and water are handled by a bucket pump driven directly by the engine. In passing through the feed-water heater, the water is heated to 120 deg. F., then going to the economizers and boilers. A general view of the water piping and the position of the boilers and pumps in their respective buildings is shown in Fig. 7.

Fig. 8 is a partial plan view of No. 3 boiler room and piping. Two 10-in. steam mains run to the pumping plants. In No. 3 station each branch pipe has a steam separator close to the engine throttle. In No. 2, the main header in the basement contains a steam separator; the separators are all drained by traps. The cylinder jackets drain into a 2-in. pipe which discharges into a pump receiver, to be returned to the boilers by two 7 and 4½ by 8-in. duplex steam pumps. The steam pipes from the main header to the pumps are 6 in. in diameter, and are taken from the header, which is in the basement in both buildings, and run to the boiler houses through a tunnel. Fig. 9 shows the position of the steam header. The lower water main is for the condenser circulating water. Two 8 and 8 by 10-in. air pumps in the basement of No. 3 pump house supply air at 105-lb. pressure for closing the top valves on the low-pressure cylinder.

In the basement there is a bypass between the suction and the discharge pipe of each pump, fitted with a relief valve. If anything obstructs the discharge line, water is discharged into the suction pipe. The large valves on the suction line are hydraulically operated.

All pumps discharge into city mains, but if the pressure exceeds the allowable pipe-line pressure, the excess water backs up into one of the reservoirs. If the pressure is reduced in the city main, water flows by gravity from the reservoir into the main, and in this way acts as a relief valve.

All pumps are equipped with an oiling system operated by compressed air. Oil is received by the carload and emptied into a 2500-gal. tank outside the building. This tank is subjected to an air pressure of 50 lb. and the oil is forced into two small galvanized-iron tanks suspended in the basement from the engine-room floor.

These small tanks are also kept under 50-lb. air pressure, which elevates the oil to the top of the engines through brass piping, from which point the oil flows by gravity to the bearings.

The water pressure on the pump intakes is 69 lb.; the steam pressure 175 lb. on the high-pressure cylinder and 12 lb. on the intermediate receiver. A vacuum of 15 in. is carried on the second receiver and of 28 in. in the condenser.

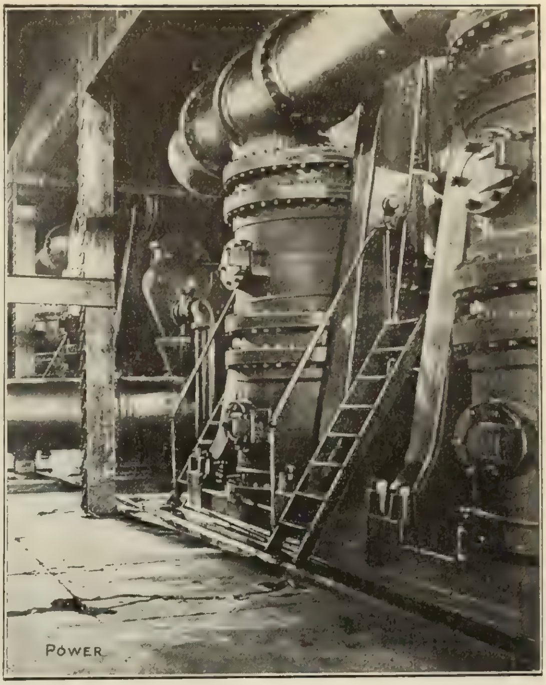


FIG. 6. WATER END OF PUMPS: ALSO JET CONDENSER

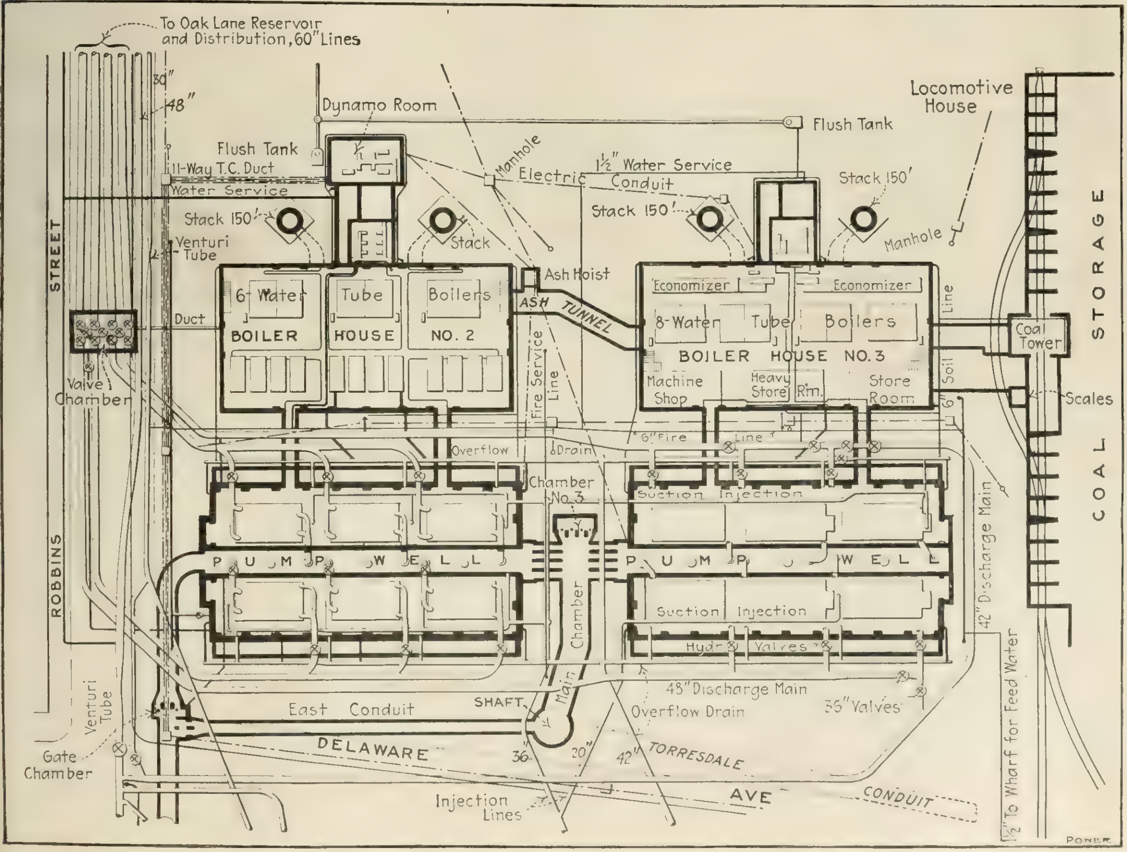


FIG. 7. WATER PIPING FOR NOS. 2 AND 3 PUMPING PLANTS

The pumps in the two pumping plants work against a head of 193 and 247 ft. Last year, these stations pumped 73,350,000,000 gal. of water, requiring 63,800 tons of coal, 15,000 gal. of engine oil, 11,600 gal. of cylinder oil and 7000 lb. of lubricating grease.

Boiler Houses

Both boiler houses of the new station are of the same general architecture; No. 2 boiler house contains six water-tube boilers of 500-hp. capacity each, equipped with mechanical stokers, and there are eight 500-hp. water-tube boilers equipped with mechanical stokers and two economizers in No. 3 boiler house. The piping of the boiler installation is shown in detail in Fig. 8. These boilers contain 252 four-inch tubes, 18 ft. long. The two steam drums are each 36-in. in diameter and are 21 ft. long.

The length of the stoker grate is 8½ ft. and the area is 102 sq.ft. The boilers are set in batteries of four each. The two 10-in. steam mains to the engine room are connected at the end, to the boilers, by 6-in. steam lines, with long-radius loops to take care of expansion and contraction. Fig. 8 gives a good idea of the piping-arrangement for the entire boiler plant. Fig. 10 is a partial view of the boiler room. Smoke and gases pass through smoke flues to four 150-ft. chimneys, each with an internal diameter of 7 ft.

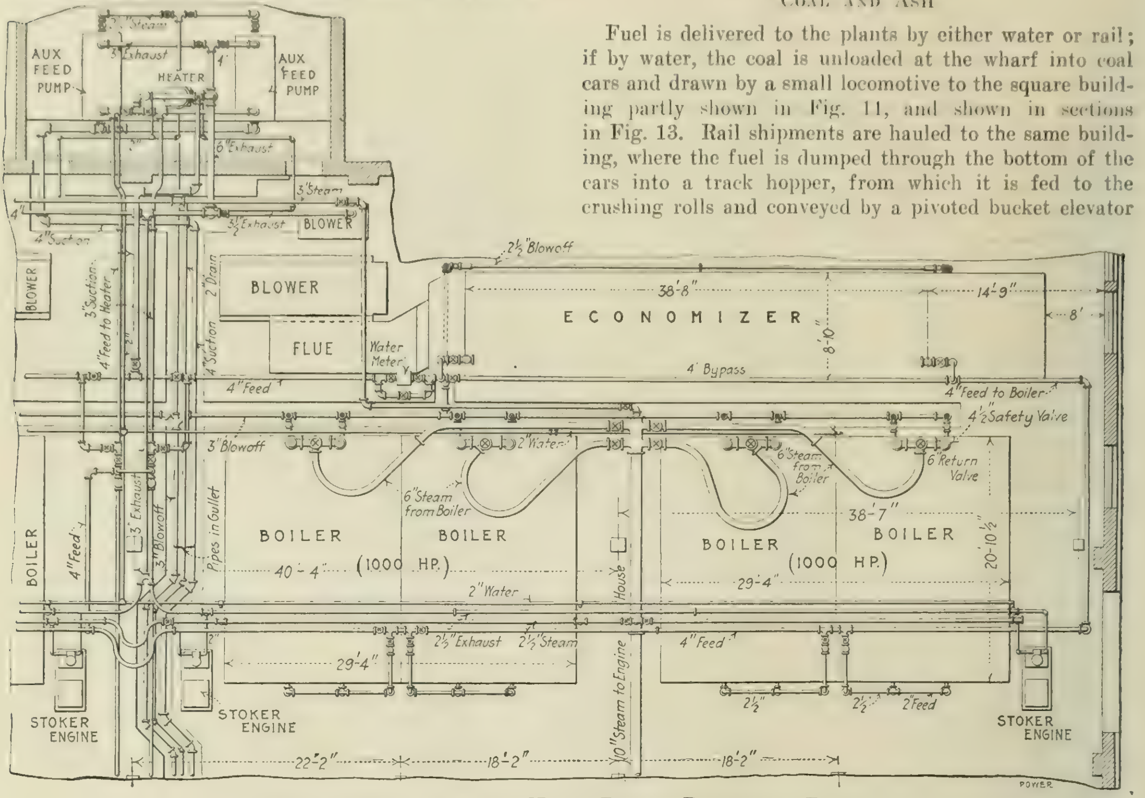


Fig. 8. Partial Plan of No. 3 Boiler Room and Piping

Economizers

At the rear of the boilers in No. 3 station are two economizers, Fig. 12, each containing 640 tubes. The flue gases leave the economizers at 300 deg., after heating the feed water from 120 deg. to 200 deg. F. The scrapers of each economizer are operated by a 7½-hp. 230-volt, direct-current motor. Two engine-driven fans supply the mechanical draft.

In case the feed pumps on the pumping engines fail to deliver sufficient boiler-feed water, auxiliary feed pumps in a pump room at the rear of the boiler can be used to supply this deficiency.

Coal and Ash

Fuel is delivered to the plants by either water or rail; if by water, the coal is unloaded at the wharf into coal cars and drawn by a small locomotive to the square building partly shown in Fig. 11, and shown in sections in Fig. 13. Rail shipments are hauled to the same building, where the fuel is dumped through the bottom of the cars into a track hopper, from which it is fed to the crushing rolls and conveyed by a pivoted bucket elevator to the top of the elevator house, and is then discharged onto a 425-ft. belt conveyor. The belt conveyor runs to both boiler rooms and discharges the coal into the coal bunkers above the boilers, of which there are two, having a total capacity of 3000 tons.

The ashpit of each boiler is divided into two sections, one for fine coal sifting through the stokers, the other for ash falling from the rear end of the stokers.

These pits have duplex gates at the bottom and the contents discharge into an end-dumping ash car running on a track in a tunnel under the boilers. All fuel is elevated from the tunnel level to the top of the track hopper, where it is dumped into the hopper and elevated to the coal bins to feed to the stoker again.

Ash is discharged into a similar car and is dumped into a skip car and elevated to the top of the ash bunker and discharged. Ashes are disposed of, either into a common coal car on the track in the elevator house and hauled away for filling-in purposes or is discharged into wagons through the spout shown at the side of the tower, Fig. 13.

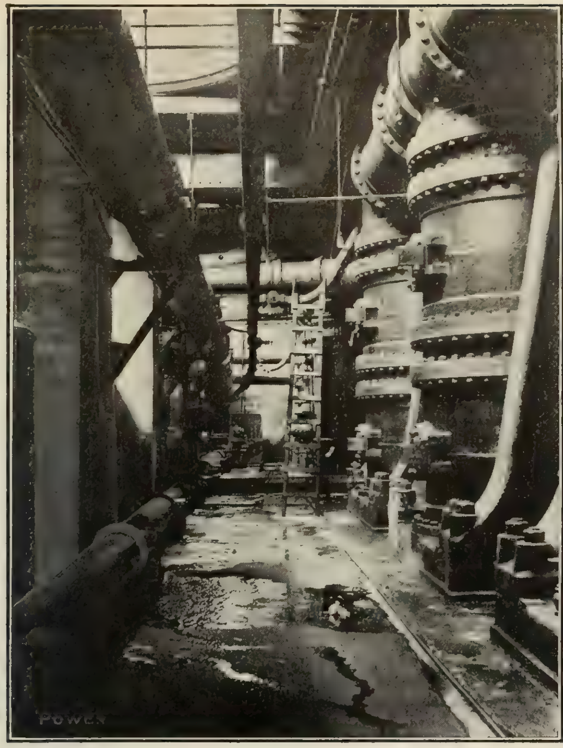


FIG. 9. STEAM HEADER IN BASEMENT; ALSO WATER MAIN

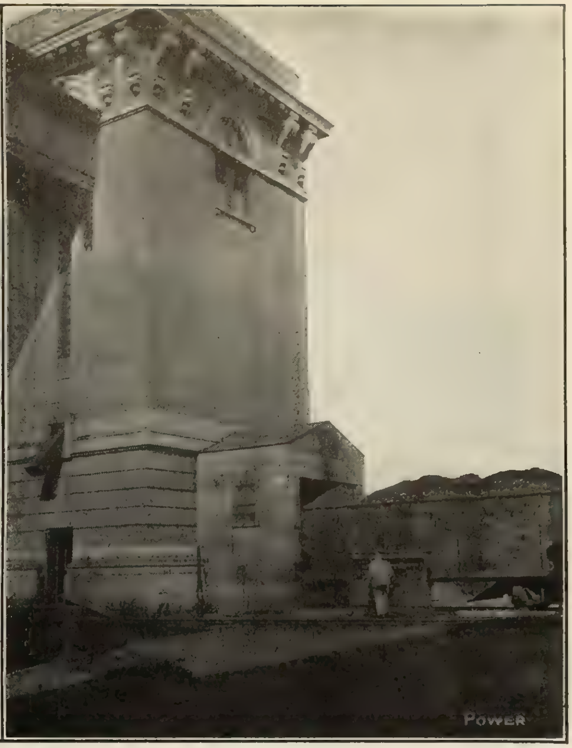


FIG. 11. WEIGHING A CAR OF COAL

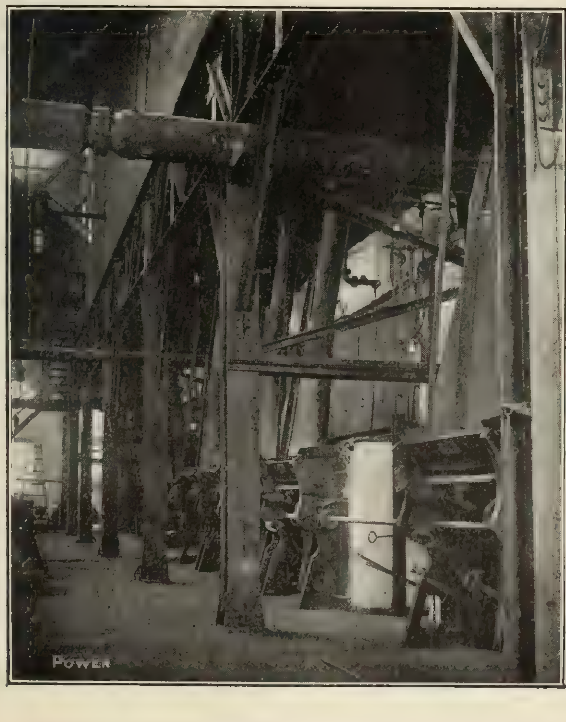


FIG. 10. VIEW OF PART OF NO. 3 BOILER ROOM

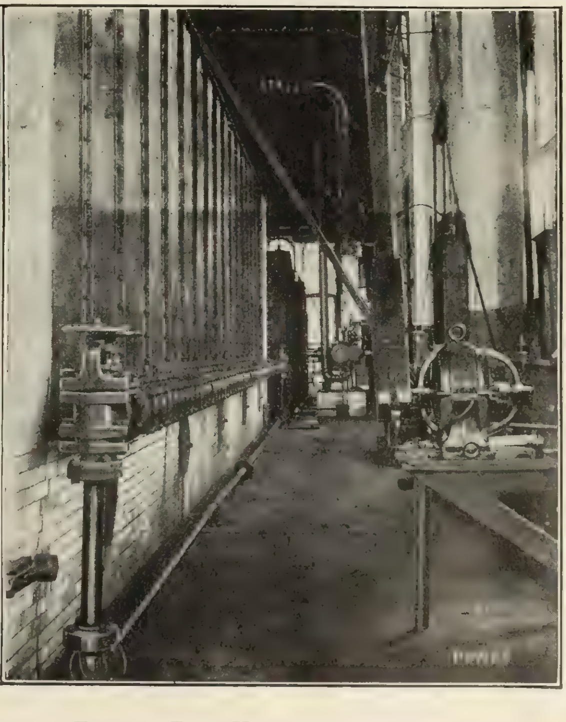


FIG. 12. REAR VIEW OF THE ECONOMIZERS

PRINCIPAL EQUIPMENT OF LARDNER'S POINT PUMPING PLANT

No. Equipment	Kind	Size	Use	Operating Conditions	Maker
12 Pumps	Vertical, triple expansion	20,000,000 gal	Pumping city water	Condensing, 175-lb. steam	Holly Mfg. Co.
14 Boilers	Water tube	500 hp	Steam generators	Natural and forced draft, 125-lb. pressure	Edge Moor Iron Co.
2 Economizers	Green		Feed water	Motor driven scrapers	Green Fuel Economizer Co.
2 Chimneys	Custodis	150 ft. high, 7 in. internal dia.	Boiler gases	Natural draft	Alphonse Custodis Chimney Con. Co.
2 Chimneys	Heinicke	150 ft. high, 7 in. internal dia.	Boiler gases	Forced draft	H. R. Heinicke
14 Stokers	Wetzel	102 sq. ft. area	Boiler furnaces	Automatic	Wetzel Mechanical Stoker Co.
4 Pumps	Air, vertical	8x8x10"	Air for closing engine valve	105 lb. pressure	Westinghouse Air Brake Co.
2 Motors	Direct current	7½ hp	Economizer scrapers	1525 r.p.m., 230 volt	General Electric Co.
1 Conveyor	Belt	840 ft. long	Coal	Intermittent	Robins Conveying Belt Co.
4 Conveyor	Bucket		Ash	Intermittent	Jeffrey Mfg. Co.
3 Engines	Center crank	90 hp	Directly connected to generators	Noncondensing, 250 r.p.m.	Ridgway Dynamo & Engine Co.
3 Generators	Direct current	50 kw	Engine driven	250 r.p.m., 250 volts	

MISCELLANEOUS

Electrical energy for operating the motors and for lighting is supplied by three 10x12-in. center-crank engines, each directly connected to a 50-kw., 250-volt, direct-current generator. These units are in the small building at the rear of No. 2 boiler house, shown at the right of Fig. 2. There is also one air compressor for blowing boiler tubes, etc.

The pumping plants of Philadelphia supply filtered water, freed of 99 per cent. of all bacteria, to approximately 326,000 homes and 1,550,000 people at a cost of less than one cent a day to each person. About 2000 men are employed by the water department and the aggregate daily capacity of all the city pumping plants is 709,000,000 gal.

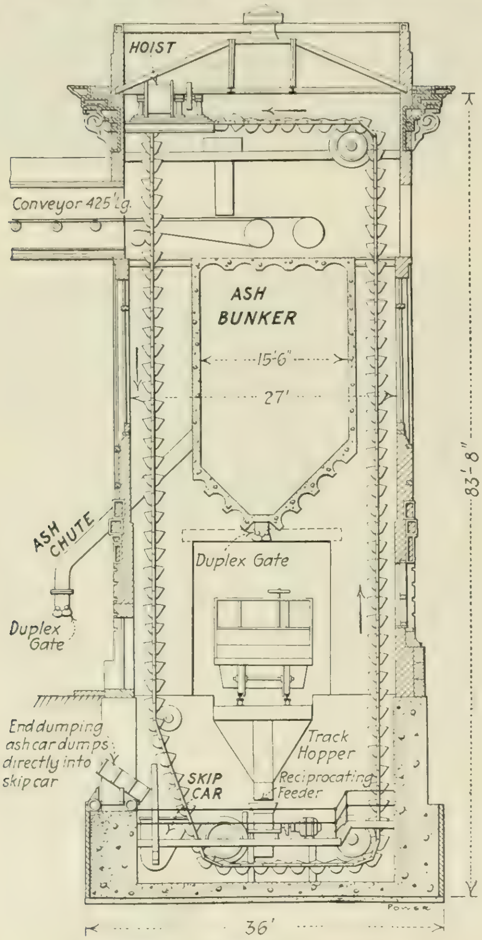


FIG. 13. SECTIONAL ELEVATION OF ASH- AND COAL-CONVEYOR HOUSE

* * *

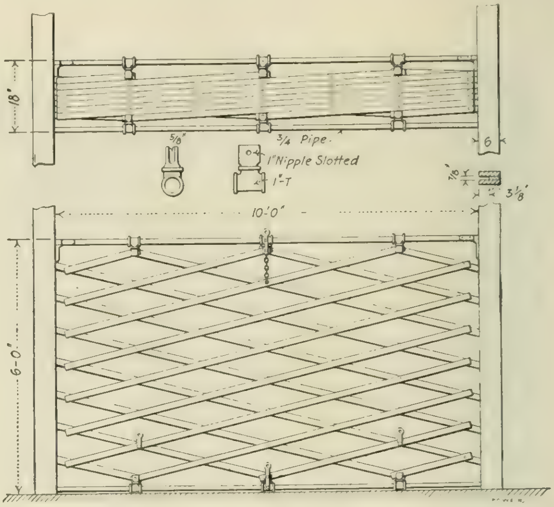
Collapsible Safety Elevator Gate

By A. G. KNIGHT

The gate shown in the drawing was originally devised to comply with the Nebraska State Factory Laws, which require that freight elevators be provided with gates 6 ft. high and reaching to the floor instead of standing on legs as commonly arranged.

There has been so much comment from elevator inspectors, architects, building owners and others that the writer believes there are many who would like to use the gate as illustrated.

The main feature of the gate is that it closes in a space of 18 in. and can, therefore, be used where there is little headroom. Its top and bottom rails are made of ¾-in. black pipe flattened at the ends. The top rail has a small lug riveted near each end, the lugs resting on little iron blocks on the slides and holding the top rail at the proper height.



COLLAPSIBLE ELEVATOR GATE

The oak slats are 1½ in. wide by ⅝ in. thick, and are put together with $\frac{5}{16}$-in. carriage bolts. A washer on each bolt between the slats reduces the friction. The chain shown in the upper part of the gate is necessary in that it keeps the gate from sagging down and getting out of the slides. These gates are quite large, have counterbalance weights attached to both top and bottom rails, and are opened by one or two ropes attached either to the bottom rail or to some part of the gate near the bottom. Different ways of opening the gate have been tried, but for a wide gate two ropes attached to the two eyes shown near the bottom of the gate are preferable.

* *

The Blackstone Oil Engine

By J. A. Seager

Most satisfactory results have been obtained with a low-compression type of crude-oil engine, developed by Blackstone & Co., Ltd., Stamford, Eng., especially for using low-grade oils. The engine employs the four-stroke cycle and a compression of about 150 lb., the air for fuel injection being supplied at 450 lb.

With compression to only 150 lb., some additional means have to be provided to ignite the charge. This is effected by a dual spraying device consisting of a main jet delivering into the combustion chamber and an auxiliary jet delivering a small constant charge into a bulb-shaped ignition chamber heated at starting by a lamp and afterward kept hot by the heat of combustion. This ignition chamber communicates with the combustion chamber by a port so arranged that the flame impinges upon and ignites the main fuel sprayed into the combustion chamber. The oil is delivered from a tank to the spraying device by a governor-controlled pump and first reaches the auxiliary or igniter spray. All oil in excess of the quantity required for this overflows into the main spray. In this way the charge of oil is injected into the igniter at every cycle, keeping it hot, whether the engine is running light or loaded.

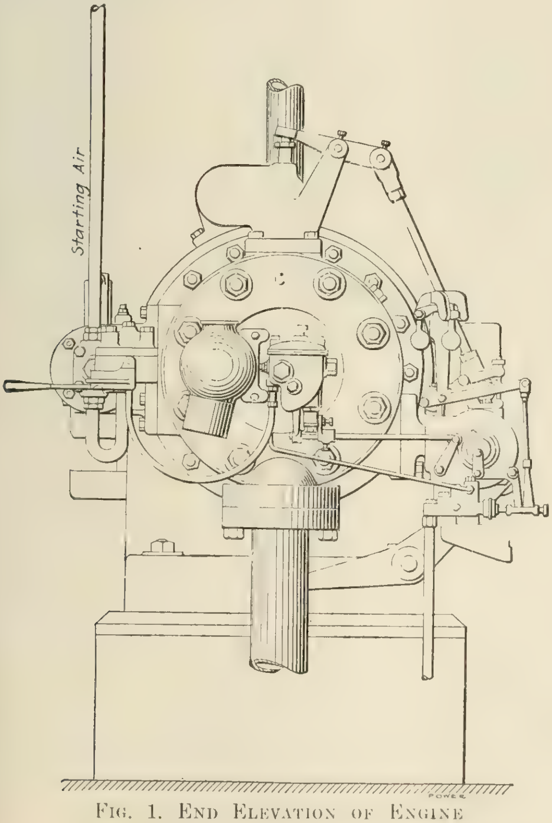


Fig. 1. End Elevation of Engine

Fig. 1 is a view of the cylinder end. The fuel is delivered to the spray chamber by a force pump, worked from the camshaft, the quantity pumped being determined by the action of the governor in raising or lowering into the pump ram. This ram travels home to a fixed point on the outward travel, and hence the length of the stroke home is dependent on the position of the wedge. If the load suddenly comes off the engine, the wedge is withdrawn, the stroke of the pump becomes nothing, and then gradually settles down to the fuel requirements.

The spray valve box and the igniter are shown in Fig. 2. In this spray box are fitted two needle valves, one, *M*, leading direct into the cylinder, the other, *N*, from the side of the spray chamber into the igniter which is a hollow bulb of cast iron kept red hot by the heat of the explosions. The opening of the main spray valve is effected by the lever *B* pressing against the inside of the spring collar, and the small tailpiece on the same lever acts upon the rocking lever *C*, causing it in turn to press at right angles upon the collar of the ignition spray valve, thus making them open together. The lift of these valves is slight, and is regulated by set-screws on the push rods. The ignition rocker lever is carried on an eccentric pin in the cover of the spray box and the correct opening of this valve is adjusted by turning the eccentric rod. This adjustment is the only one necessary for any class of fuel and must be made with the engine running.

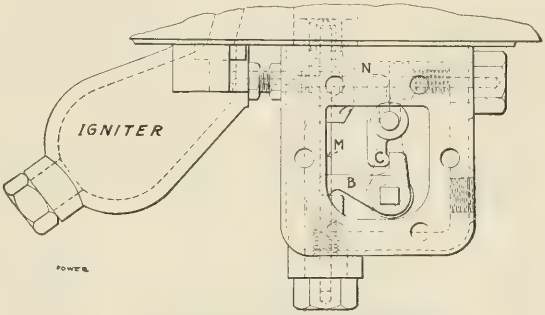


Fig. 2. Igniter and Fuel Valves

The oil enters the spray box through an annular passage around the stem of the ignition valve, overflowing to the main spray chamber. Thus the quantity entering the igniter is fixed and independent of the load. The spray valve is so arranged that the oil cannot be blown in all at once but is gradually sprayed into the cylinder meeting the jet of flame issuing from the igniter. The result is that the oil burns rather than explodes, the maximum pressure being only about 320 lb., although the mean effective pressure is said to be about 90 lb.

The valves are totally inclosed in a box in contrast to the usual arrangement of working the spraying valves through a packing gland. No mechanical atomizer with restricted ports is used, the fuel being simply blown into the cylinder by the air at 400 lb. pressure when the spray valve is opened. The compressor is of the two-stage, intercooled type with solid pistons of two diameters, the larger diameter compressing to 80 lb., and the smaller to 400 lb.

In a paper read before the Liverpool Engineering Society in March last, W. A. Simper gave some interesting figures of fuel consumption of various sizes of this engine. These are given in the following table:

FUEL CONSUMPTION AT DIFFERENT LOADS

I.Hp.	B.hp.	Full Load, Lb.	¾ Lb.	½ Lb.	¼ Load Lb.
19	15	0.57	0.61	0.69	0.93
25	20	0.52	0.55	0.625	0.84
37.50	30	0.5	0.533	0.6	0.8
56.25	45	0.48	0.52	0.575	0.76
75	60	0.47	0.5	0.56	0.75
113	90	0.46	0.49	0.55	0.73
150	120	0.45	0.48	0.54	0.72

The engines are constructed at present in single units with cylinders up to 20 in. in diameter and with two engines arranged in the twin type, powers up to 300 hp. at moderate speeds being developed. Owing to the low maximum pressure and the continued slow burning of the fuel, good speed regulation is claimed to be had without employing excessively heavy flywheels.

* *

Solving the Cinder Problem at Waterside--IV

By Charles H. Bromley

SYNOPSIS—Revolving fans with large blades carrying perforated water pipes are placed in the flues and the base of the stack to take out the cinder in the gases. A cinder catcher on the top of the stack confines the solids in a hood from which they are pulled out by vacuum. Discovery of the successful cinder catcher. Evolving the successful apparatus.

*

It was realized, after several dry-cinder catchers were used, that apparatus wherein water was introduced into the path of the gases produced the best results.

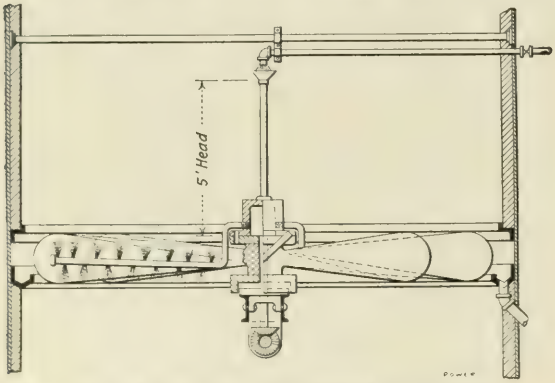


Fig. 14. Fan with Water Spray in Flue

An interesting apparatus using water, and one which would undoubtedly work successfully in some plants, consists essentially of large fans in the flues, each fan being driven by a motor outside the flue. The fan blades carry perforated water pipes to throw numerous sprays of water through the gases as the fan revolves, thus throwing down the cinder, which is gathered in a trough and washed out of the flue. Fig. 14 shows the details of one of the fans, its gear drive and its water connections. Another style of fan having the water inlet on top and running on a roller or ball bearing was also used.

Troubles of All Water-Spray Cinder Catchers

One of the chief troubles with all water-spray cinder catchers in the flues and the stack is that the perforations in the water-pipe plug with cinder, scale, salt, etc., particularly if the holes are small to give a fine jet; if they are large the jet or spray is far less efficient. Where salt water is used in such spraying apparatus, the equipment scales and becomes plugged with the salt which is deposited as the water evaporates, due to the heat of the flue gases. This deposit at the Waterside plants contains about 85 per cent. of salt, the remaining content being ash and carbon. The water is taken from the East River.

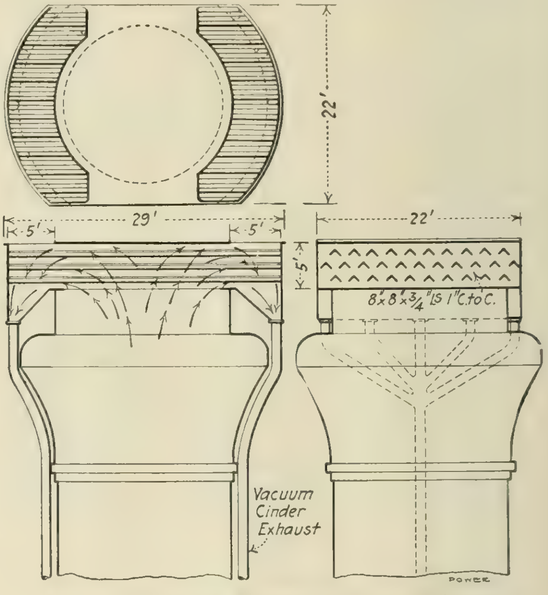


Fig. 15. Vacuum Hoods on Top of Stacks

Vacuum Hoods for Smoke-Stacks

At Waterside No. 1 station, hoods were put on top of the smoke-stacks to catch the cinder; a hood consists of a shell perforated all around its circumference. Inside the shell were placed bars in lattice-work fashion to impede the progress of the cinder, which would then drop into the hopper-like sides of the hood and be sucked away by vacuum maintained by a pump in the plant. Fig. 15 shows the arrangement.

Another method tried was an electric cinder arrester, the intention being to precipitate the suspended particles by giving them an electric charge, so that they would be driven toward a series of collecting electrodes. After experimenting with this apparatus for some time, it was given up. The efficiency shown was not high enough, serious difficulties arose with the insulation under the high potentials employed, and the covering of cinder on the insulators dissipated the charge.

Evolving the Successful Cinder Catcher

The first experimental all-wet apparatus for cleaning the gases was a curved baffle-plate placed just beyond the boiler outlet, to deflect the gases in a downward direction, with a water tank below to catch the cinder. This simple apparatus having caught a large amount of the cinder, the next step was to increase the distance traveled by the gases in the downward direction and increase the velocity of the gases to forcibly project them upon the surface of the water, thus trapping a larger percentage of the cinder. This experimental apparatus gave good results. Fig. 16 shows two applications of this plan.

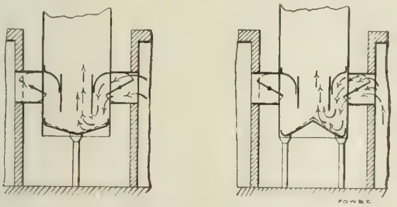


Fig. 16. The First Wet-Cinder Catcher; Two Schemes

The gases were conducted downward through a four-sided, wedge-shaped duct tapering toward the outlet, three sides being vertical and the other inclined. The water level in the tank was maintained at 12 in. from the bottom of the duct.

While this outfit was being developed, another plan of wet cleaning was being tried out at Waterside No. 1. The lower-floor boilers at that station discharged their gases downward into a flue in the basement. An inclined baffle was placed in the flue, and a sheet of water was maintained flowing over the upper surface of the baffle, so that the gases would drive the suspended solids against and into the water, which, with the trapped cinder, ran out at the bottom of the flue. End and side sectional elevations of this catcher are shown in Fig. 17. A concrete mattress used in the bottom of the flue in Waterside No. 1 lasted only a few weeks, due to the action of the water, the acids and the heat.

The next plan was to combine the stationary baffle and water sheet of the last apparatus with the baffle of the first outfit, to increase the velocity of the gases. The results were so satisfying that an apparatus, similar in general but differing in important details, was made and installed in Waterside No. 2 station.

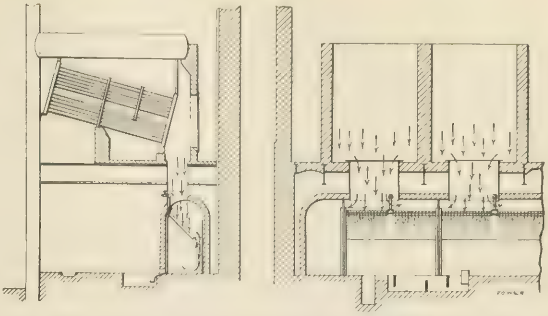


Fig. 17. Another Application of the Wet Process

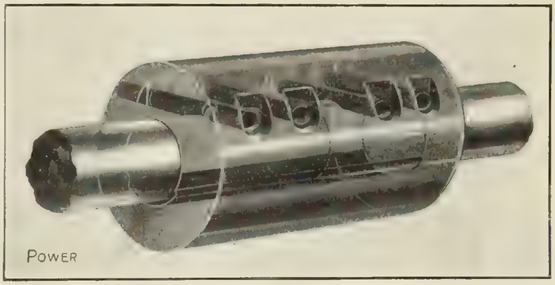
This new and successful apparatus, its details and the trouble encountered in its operation, will be described in an early issue.

⁂

Safety Shaft Coupling

The illustration shows a safety self-keying shaft coupling, recently developed by the Thomas Coupling Co., Warren, Penn., and made in two sizes for shafts from $1\frac{3}{16}$ to $2\frac{15}{16}$ and 3 to 6 in., respectively.

It consists of a round iron or steel casting, through which a hole is bored lengthwise to accommodate the ends of the shafts to be coupled. Lengthwise through the bore a clearance space is milled which allows for two bearing spaces the length of the coupling. At the side of the coupling and transverse to the bore are the key holes, accurately laid out and drilled, entering a portion of the bore. In these small side holes cupped-end tool-steel pins are forced to a drive fit. These pins are easily driven with an ordinary hammer, cutting away the portion of the shaft which extends above the bed of the pin, thus locking the shaft both ways and eliminating the necessity of keyseating the shafting. It will be noted that this type of coupling is devoid of projecting parts.



Safety Shaft Coupling

⁂

Largest Pelton Wheel in Switzerland—The Swiss hydraulic plant situated on the Lontsch River is using what is claimed to be the largest Pelton wheel in Europe, the wheel being of 15,000-hp. capacity. In this station there are six Pelton wheels of 6500 hp., so that this latest wheel brings the output of the Lontsch plant up to 54,000 hp. The plant is one of the largest in Switzerland.

Wreck of Corliss Engine

By Charles O. Wilkes

A 150-hp. Corliss engine at the Athens Brick Co., Athens, Ohio, wrecked itself recently, doing considerable damage to the building and a fine residence about 700 ft. distant.

The 16-ft. flywheel, having a 15-in. face and weighing about 10 tons, was completely demolished and thrown through a 12-in. wall, breaking a 10-in. steam-exhaust line, throwing it and many other obstacles in every direction. Other steam lines were broken, as was the safety valve on one of the boilers, allowing live steam to fill the boiler and engine rooms. Fortunately, no lives were lost though one man was trapped in the engine room at the time of the accident.

Photographs will tell more than words and still not fully describe the damage done. Fig. 1 shows a view through the engine room from the boiler room, taken through an opening in the 12-in. wall made by the bursting wheel. The 12-in. shaft is seen to be bent and the hub of the wheel still mounted and keyed in position. This hub weighs nearly a ton. The cap on the main bearing has been lifted and the engine bed beneath the main bearing broken.

In the distance is the large driven pulley which was not damaged despite the flying missiles. At the immediate right can be seen an opening in the wall made by the leather belt when it broke, heavily striking against the brick, crowding the wall out and breaking back about 4 ft. into the wall at the immediate right.

Fig. 2 shows only a small part of the distortion of the crank and connecting-rod. Only one more revolution would have been sufficient to completely wreck the cylinder, which was uninjured, so far as could be seen. This and some parts of the valve-gear were all that were worth saving.

Fig. 3 shows the engine room on the opposite side from that shown in Fig. 1. It shows also the opening in the 12-in. wall into the boiler room, indicating the damage done to the boiler setting and to the roof of the building. In this view one of the spokes of the flywheel is being removed. Two of them were found in the boiler room in a small alleyway where the fireman had started through to the engine room when it became evident that he could not prevent an accident. Seeing his danger and knowing he could not reach the engine in time, he turned and had just made his escape when the accident occurred.

A man employed to wheel coal into the boiler room was emptying a wheelbarrow when the fireman (who fell headlong into the coal pile) scrambled to his feet and shouted, "Look out!" He was greeted with an unconcerned "Huh?" The fireman had just found shelter

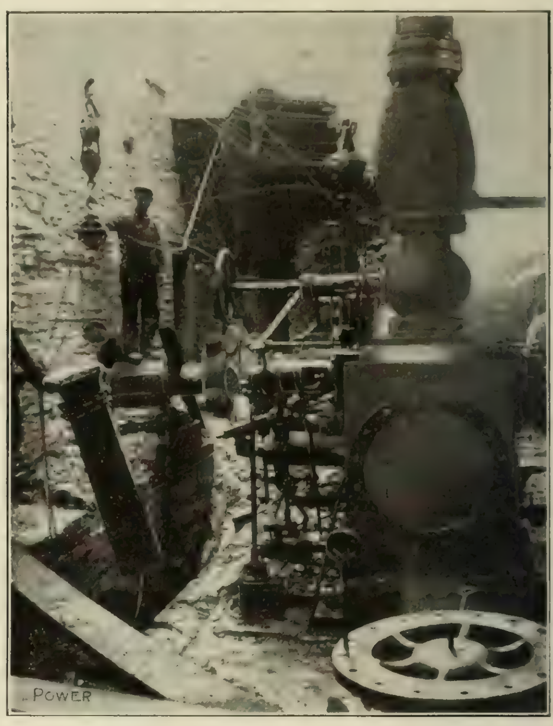


Fig. 3. Damaged Boiler Setting in Rear

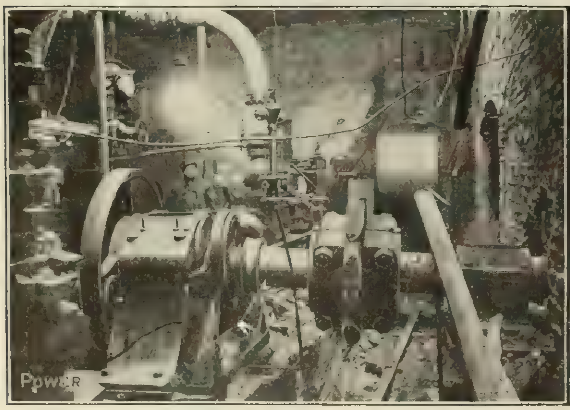


Fig. 1. General View of Engine Room

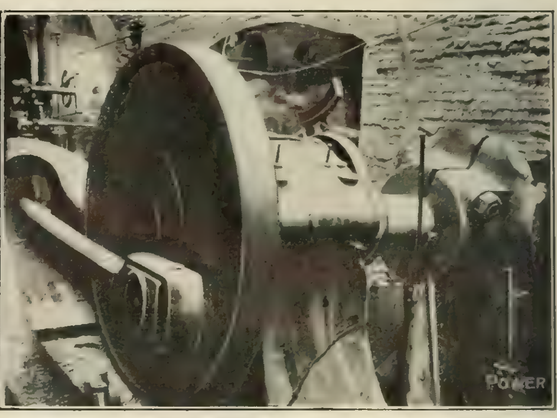


Fig. 2. Cracked Pillow Block and Bent Rod

beneath a carload of coal when iron, bricks and everything movable came showering down. He came out only to find his fellow employee unloading the wheelbarrow.

The real cause of the accident is unknown, although it is thought to have been due to a slipping governor belt that allowed the engine to exceed the critical speed. If the belt had broken it would have allowed the idler wheel-lever to drop and so stop the engine.

* *

Terry "Return-Flow" Turbine

SYNOPSIS—A new Terry product of the combined velocity- and pressure-stage type designed to run condensing. The low-pressure nozzles are mounted in detachable segments on the diaphragms. The cylindrical bearing housings and suspended casing are features of the design. Forced-feed lubrication is provided.

*

THE "RETURN-FLOW" FEATURE

The most common of Terry turbines familiar to engineers is of the velocity-stage type using one rotor and redirecting buckets, and run noncondensing. The latest Terry machine, Fig. 1, has been designed to operate condensing and, for the present, at least, will be made in sizes up to 500 kw. It is a combination multivelocity- and pressure-stage machine, using one wheel and redirecting buckets for the high-pressure end, and a series of multipressure-stage elements for the low-pressure end, as in Fig. 3

As indicated by the arrows in the sectional view, Fig. 3, the steam, after being used and expanded to slightly above atmospheric pressure in the velocity-stage chamber, is conducted to the pressure-stage lower-pressure end which is reversed; that is, the flow of steam through it is in a direction opposite to that at which the initial pressure steam entered. It is this feature which gives the turbine its name of "return flow."

STEAM-SEALED SHAFT-GLANDS

This design admits of constructing a unit that is not only compact but one in which the glands are sealed against air leakage without the use of water seals or a pumping equipment. The external shaft-glands are sealed against leakage by steam at a pressure slightly above atmospheric, as in Fig. 3, the tinted area of which indicates the part subjected to vacuum. It is sometimes difficult to tell if increased air leakage into the vacuum system and consequent reduction in vacuum is due to leaks at the shaft-glands or elsewhere, but with this design the leakage must be looked for elsewhere.

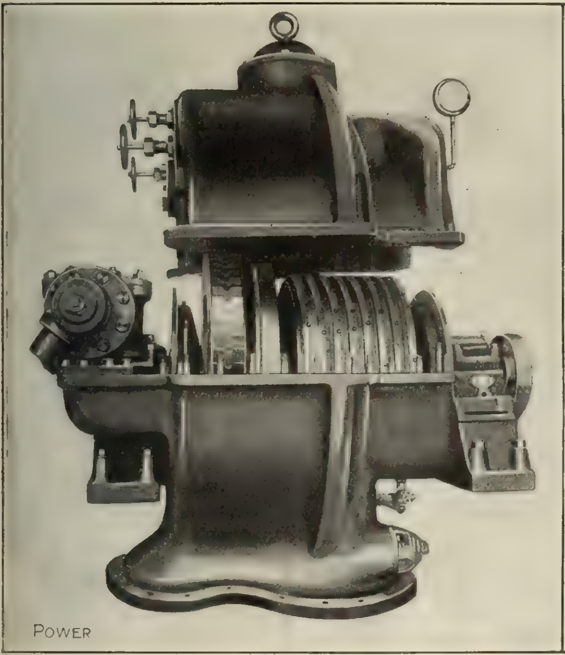


FIG. 1. THE "RETURN-FLOW" TURBINE

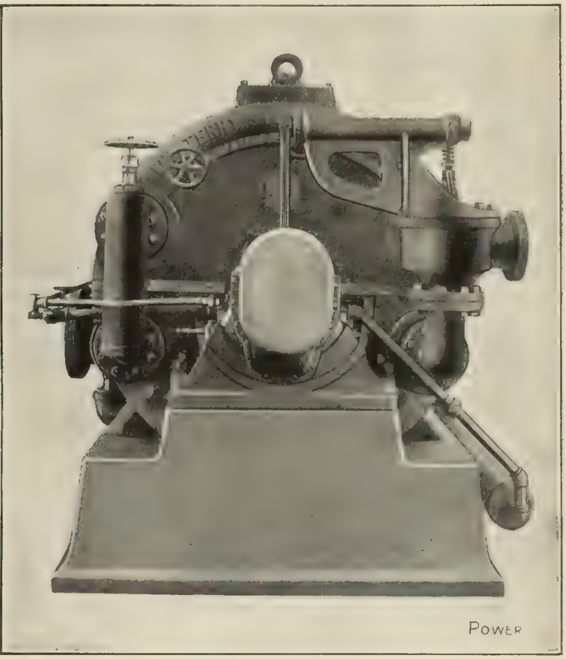


FIG. 2. SHOWING FEATURES OF DESIGN

NOZZLES MOUNTED ON DETACHABLE SEGMENTS

The nozzles for the low-pressure end are of drawn material with hardened surfaces, and are mounted on annular rings made in segments, any of which may be removed without disturbing the rest. This is of decided advantage, because it is possible to inspect or remove any blades without cutting or disturbing those adjacent. The blades are held by riveted, removable key-pieces and are shrouded.

The rotor rests on pedestal bearings supported directly from the baseplate. In Fig. 3, note that the seats for the bearing housings are cylindrical, being bored at the same setting with the casing, which, as shown, is not supported by feet resting on the baseplate, but is suspended from the bearing. This feature is commendable, as the operator need experience no difficulty in lining up the machine if he should dismantle it, for when the bearing housings are pulled down on their seat the rotor must come concentric with the casing. The flow of steam through the turbine tends to equalize the temperatures of the ends and to avoid distortion due to expansion and contraction. To further assist in this by reducing the conduction of heat from the pedestal blocks to the bearings, the blocks are hollow, with a hole in each for air circulation, and the cylindrical seats consist of two strips with an air pocket between them.

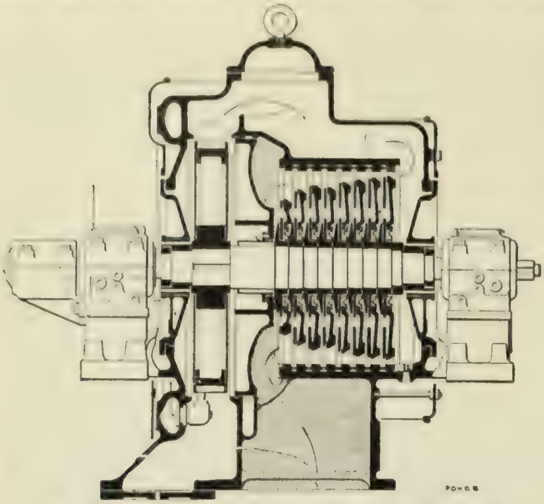


FIG. 3. SECTION OF "RETURN-FLOW" TURBINE

The governor, of the direct type, operates the double-seated regulating valve through levers and a ball-bearing rocker shaft. For alternating-current units either a hand- or a remote-controlled synchronizing device is furnished. The regulating valve is, of course, of the double-seated balanced type and is provided with a heavy cylindrical screen which completely surrounds the valve seats and allows for a large annular space between the valve body and the screen.

LUBRICATION

The bearings are water-jacketed and supplied with forced-feed lubrication by a screw-type oil pump in the baseplate between the turbine and the driven unit. Ring-oiling lubrication is also provided to be used when emergencies demand.

⁂ ⁂

Calculating Power in Alternating-Current Circuits--I

By NORMAN G. MEADE

SYNOPSIS—A simple explanation of the terms power factor, wattless current, self induction and capacity; also how they are determined.

⁂

Engineers and electricians having charge of circuits with induction-motor loads realize the difficulty of keeping up the power factor of the system. No matter how much care is taken to install motors whose rated capacity is close to the power requirements, the power factor is still regarded by many as a "skeleton in the power-house closet."

POWER FACTOR

In direct-current circuits the product of the simultaneous readings of the voltmeter and ammeter give the watts delivered. With alternating current this product gives the apparent power only, which may be greater than the real watts as indicated by a wattmeter connected to the circuit. The ratio of the wattmeter reading to the product of the voltmeter and ammeter readings is called the power factor. This is never greater than unity, and is usually expressed in percentage. If the true power is expressed in kilowatts and the apparent power as the product of kilovolts (1000 volts) and amperes, then the following relations will be found to hold true:

$$\textit{power factor} = \frac{\textit{real watts}}{\textit{apparent watts}} = \frac{\textit{kilowatts}}{\textit{kilovolt-amperes}}$$

The power factor may also be considered as equal to the cosine of the angle of lag or lead of the current behind or ahead of the electromotive force. In Fig. 1, *OE* represents the electromotive force and *OC* the current, 45 deg. behind the electromotive force. The relation of electromotive force and current is also illustrated by the sine curves representing one complete cycle. It will be seen that the electromotive force has reached a value corresponding to *E'* before the current starts from *O*, 45 deg. behind it.

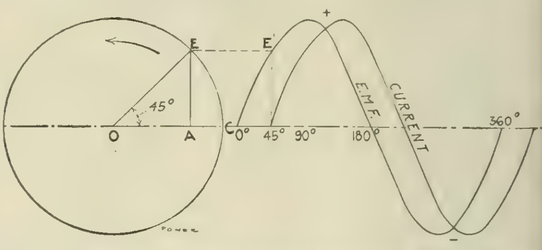


FIG. 1. GRAPHICAL REPRESENTATION OF CURRENT AND VOLTAGE VALUES

The vertical line *AE* is called the sine of the angle, and the horizontal distance *OA* is the cosine. From tables of natural trigonometrical functions the cosine of 45 deg. is found to be 0.707; hence the power factor is 0.707, or approximately 0.71. When the angle of lead or lag is 90 deg., the cosine of the angle is zero and the true watts expended are zero; that is, the current is said to be wattless. When the angle becomes greater than 90 deg., the cosine becomes negative, thus showing that the machine, if a motor, is delivering energy to the circuit. From the foregoing, it becomes evident that it is possible to have large alternating currents flowing under high electromotive forces and at the same time have but little energy expended.

For a given amount of power transmitted, the current will be smaller if the power factor is high than if low.

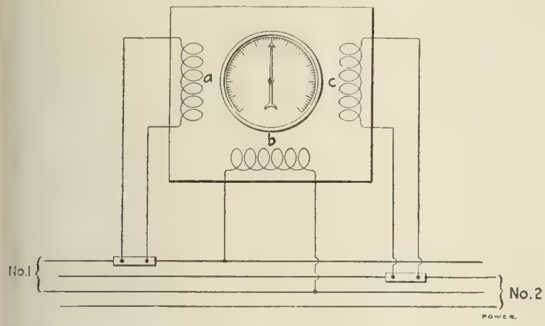


Fig. 2. Representing Connections of Power-Factor Meter

Let it be desired to transmit 100 kw. over a line by means of alternating current, the load consisting principally of motors, and assume that the current lags behind the electromotive force by an angle of 25 deg. The cosine of an angle of 25 deg. equals 0.90; therefore the power factor will be 90 per cent., and

$$\textit{true watts} = \textit{volts} \times \textit{amperes} \times 0.90$$

Assume the line pressure to be 1000 volts. The power delivered is 100 kw., or 100,000 watts; then the current equals

$$100{,}000 \div (1000 \times 0.90) = 111.1\ \textit{amp.}$$

instead of 100 amp. with unity power factor. This illustrates the necessity of maintaining as high a power factor as possible.

Wattless and Power Components

Current in an alternating circuit to which an inductive load is connected can be considered, as resolved into two components, one at right angles to the electromotive force and one in phase with it. The component at right angles is known as the wattless component, and that in phase with the electromotive force as the power component. The greater the angle of lag or lead of the current the larger will be the wattless component and the smaller the part which is really expending power in the circuit.

Although wattless currents do not represent any power wasted, they are objectionable, because they load up the lines and the generators, and limit the current-carrying capacity. For example, assume a generator supplying 30 amp. to a system with a low power factor. The actual power delivered would be small and the prime mover driving the generator would be lightly loaded, but the current of 30 amp. is circulating through the lines and the armature of the generator, loading the lines and heating up the machine. As the current output of the armature is largely limited by heating, the useful current which the generator could deliver is greatly reduced by the wattless component.

Measurement of Power Factor

The power factor is measured by a phase-angle indicator or power-factor meter; the connections for a two-phase instrument of this type are shown diagrammatically in Fig. 2. The current in the series coils *a* and *c* produce a rotating field, and that in the shunt coil *b* produces an oscillating field. The shunt coil is free to rotate and will take up a position in which its oscillating field will be in time phase with the resultant rotating field in that plane. If the electromotive force is in phase with the current, the coil, to which a pointer is attached, will assume the position shown by the pointer.

Power-factor meters are always installed with series transformers in the series circuits, the current in the coils being limited to from 3 to 5 amp. Frequency has no effect upon the accuracy of the readings, but unbalancing of the phases may cause serious errors.

The connections can be checked by disconnecting the voltage coil and noting the direction of rotation of the pointer. If the series coils are not properly connected, the pointer will either rotate in the lag direction or not at all. The mechanism is mounted in a case provided with a dial with the zero mark at the center; lagging and leading currents are scaled off right and left from zero, the divisions representing the percentage of power factor.

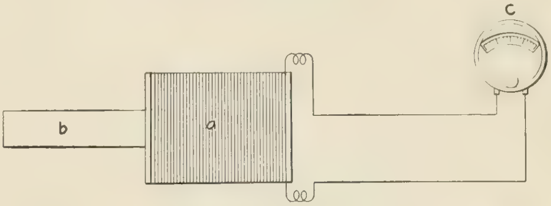


FIG 3

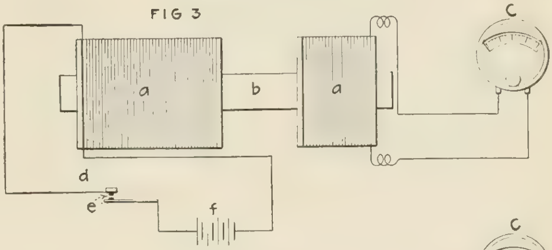


FIG. 4

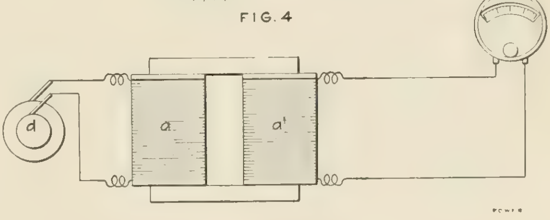


FIG. 5

Figs. 3, 4 and 5. Illustrating Self-Induction

Self-Induction and Capacity

Power factor has been defined and its effects illustrated, now the causes for leading and lagging currents will be considered. A load consisting entirely of incandescent lamps is practically noninductive, but where are lamps and induction motors form the load, or part of it, self induction is always present and a lagging current results.

Whenever the number of magnetic lines of force threading through a circuit is caused to change in any way an electromotive force is set up in the circuit, and the average electromotive force so generated depends upon the average number of lines of force changed per second. For illustration, let *a*, Fig. 3, represent a coil of wire or solenoid, *b* a permanent magnet and *c* a low-reading voltmeter or a galvanometer. Lines of force may be made to thread through the coil by inserting the permanent magnet in its center opening and then moving it backward and forward so as to cause the number of lines passing through the coil to vary. This will establish an electromotive force as indicated by the voltmeter. The electromotive force so generated will be alternating.

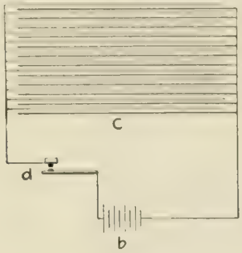


FIG. 6

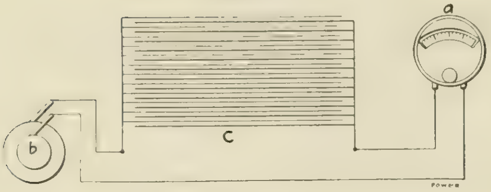


FIG. 7

Figs. 6 and 7. Illustrating Capacity

Now consider Fig. 4, where *a* and *a'* are coils wound on a core of soft iron *b*; *c* is a voltmeter, *d* a key with contacts *e* and batteries *f*. When the key is closed the current flows in coil *a*, magnetizing the core *b*. The lines of force rise from zero to maximum and cut the turns of wire in coil *a'*, causing an induced current to flow for a fraction of a second, and the voltmeter *c* will show a deflection. Upon opening the key the current in *a* will cease and the lines of force set up in the core will fall from maximum to zero, during which time current will again be induced in *a'*, but in a direction opposite to that when the key was closed.

Finally consider two coils, *a* and *a'*, as in Fig. 5, the former connected to a source of alternating current. An alternating current will be established in *a'* and the voltmeter *c* will show a continuous indication.

Lines of force may also be made to thread a coil by sending a current through the coil itself. If a current be sent through a coil, lines of force will be set up about it, the path being through the core and back through the surrounding air to the opposite end of the core. So long as the current remains steady, these lines will not change, and the current will flow through the coil just as though it were an ordinary resistance; that is, the current would follow Ohm's law. If there is a variation in the current, however, there will also be a variation in the number of lines of force threading the coil; therefore there will be an electromotive force set up in the coil. This electromotive force of self-induction tends to oppose any change in the current. In direct-current circuits there are no self-induction effects as the current is steady and no induced electromotive forces can be set up.

Circuits containing resistance can be made which have practically no self-induction and are known as noninductive resistances; such circuits are governed by Ohm's law and incandescent lamps or water resistances are good examples.

So far, only lagging current has been considered, but circuits containing capacity in excess of self-induction cause the current to lead the electromotive force. The property which most circuits possess of holding charges of electricity is known as electrostatic capacity. In underground cables the capacity effect is important as the copper conductor and the lead sheathing act similar to a condenser.

If it is desired to introduce capacity in a circuit, a condenser is generally employed. A condenser consists of a number of sheets of tinfoil separated by oil paper, mica or other suitable insulating material. Every alternate strip is connected to a common conductor and the remaining sheets to another conductor, as in Figs. 6 and 7, there being no electrical connection between the two sides of the circuit. If a battery *b* is placed in circuit with the condenser *c*, by means of the key *d*, current will flow into the condenser for a fraction of a second and then cease when the condenser is said to be charged. If, then, the battery is disconnected and the condenser terminals connected, the condenser will discharge.

In Fig. 7, the condenser *c* is connected in circuit with an alternating-current generator and an ammeter *a*. When the generator is in operation the ammeter will show a continuous reading, although there is no electrical connection to establish a circuit. If direct current were applied the ammeter would show no reading.

The effect of capacity in a circuit is exactly opposite that of self-induction and tends to give a leading current. When capacity and self-induction are both present in a circuit, one tends to neutralize the other.

The unit of capacity of a condenser is called the farad and represents a current of one ampere flowing for one second, which raises the pressure across the condenser terminals to one volt. The farad is too large a unit for convenient use and instead of it the practical unit, the microfarad, has been adopted; this equals one one-millionth of a farad.

⁂

Unique Emergency Power Plant

When a manufacturing plant has to replace an inadequate battery of boilers with one of greater capacity, it is not a simple matter to make the change without interrupting operation. This condition confronted Schaum & Uhlinger, Inc., Philadelphia, Penn., makers of textile machinery and centrifugal hydro-extractors. Buying current from the local company was too expensive, so the idea of utilizing locomotives was considered. The location of the plant, on the Pennsylvania main line, made feasible the storage of locomotives on a freight siding.

It remained a problem, however, to get locomotives of the proper capacity; in these days of heavy railroading small engines are rather difficult to obtain.

Two "American" type locomotives were finally obtained from the Pennsylvania at a reasonable rental. While these were doing service, the old battery of two boilers was replaced with a 462-hp. Heine boiler, fired by a Taylor stoker. The furnace has an extension grate, giving enough area to insure absolute combustion without necessitating a brick arch. An American blower is used for forced drafts.

The process of substitution was simple but effective. The two old locomotives, whose connecting-rods and valve-gears had long been disconnected, were hauled to a convenient point on the siding after the tenders had been uncoupled, the throttle valves were closed, and a connection piped from the auxiliary domes over the fireboxes to the main steam lines in the plant. Their positions, back to back, with an elevated platform erected between them, allowed sufficient space for two firemen and a good coal supply that could be replenished without interrupting the service.

This means of steam supply is hardly economical enough to warrant its retention for a protracted period, since the amount of coal consumed per horsepower-hour is far greater than the average manufacturing plant can afford, but there is no question that money for the excess coal consumption, in addition to the moderate rental and the labor, is well spent when a continuous steam supply is assured that keeps the plant in operation during the installation of the new boilers, and whose connection with the main steam supply can be made in a short time at night without stopping operations.

* *

Use of the Pitot Tube*

Pressure readings of 1 in. or less should be taken on an Ellison differential draft gage, graduated to at least hundredths of an inch, and calibrated by a hook gage; over 1 in., either with an Ellison gage or with a U-tube graduated to at least tenths of an inch. Great care should be exercised to have perfectly tight connections, especially on the static side. A slight loss of pressure here will cause a correspondingly high velocity pressure reading, and therefore indicate too great a velocity.

The reading should be taken at a cross-section where the pipe is straight and the flow undisturbed, preferably at least 10 diameters from the fan outlet, from an elbow, or from a change in cross-section in the duct. This condition is difficult of attainment in many installations and where it cannot be had the average of the maximum practicable number of readings at the point farthest away from the outlet or obstruction should be taken. Take the readings over a plane at right angles to, with the tube pointed in a direction parallel to, the direction of the air flow.

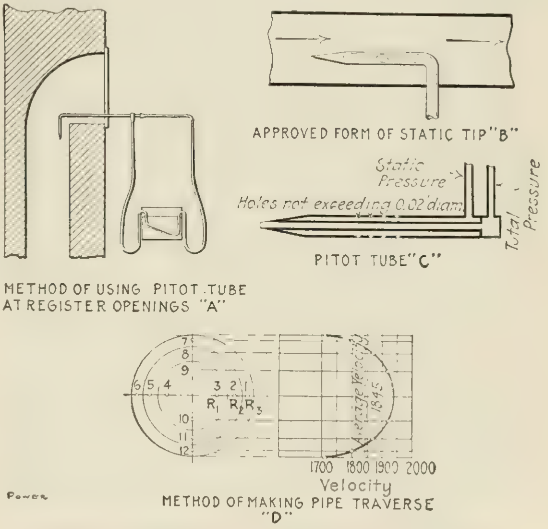
Pressure readings cannot be made over the face of an outlet with a pitot tube as is done with anemometer, but by inserting the tube in the pipe at the edge of the outlet with the tip of the tube pointed against the air flow, under the same conditions as in diagram *A*; a traverse of the pipe can be made at a point just before it reaches the outlet.

The most difficult reading to take accurately in a current of air is the static pressure. The approved form of static tip diagram *B*, is that recommended for fan-testing work. There should be eight or more clean holes 0.02 in. in diameter, an equal number on each side of a ¼-in. tube $\frac{1}{32}$ in. thick.

The most approved form of pitot tube combines the foregoing static tip with an impact tube, diagram *C*, by means of which total, static or velocity pressure may be read.

In making a traverse of a rectangular duct the cross-sectional area may be divided into a number of smaller rectangles and a reading taken in the center of each small rectangle.

A round pipe should be divided into at least three concentric zones of equal area per foot in diameter, and four readings taken on a circle drawn through the center of area of each zone or ring; that is, readings should be taken across the horizontal and vertical axis of the pipe, diagram *D*. Table 1 gives the distances from the center of the pipe to the points of reading, expressed in percentage of the pipe diameter. To get exact results a small pipe should be divided into relatively more zones than a pipe of larger diameter as the ratio of frictional surface to cross-sectional area is greater; hence the more static pressure in proportion to the impact pressure, which correspondingly reduces the velocity pressure.



APPROVED FORM OF STATIC TIP "B"

PITOT TUBE "C"

METHOD OF USING PITOT TUBE AT REGISTER OPENINGS "A"

METHOD OF MAKING PIPE TRAVERSE "D"

STANDARD METHODS OF USING THE PITOT TUBE

TABLE I. PIPE TRAVERSE FOR PITOT TUBE READINGS

Distance from Center of Pipe to Point of Reading in Per Cent. of Pipe Diameter

No. of Equal Areas in Traverse	No. of Readings	1st R_1	2nd R_2	3rd R_3	4th R_4	5th R_5	6th R_6	7th R_7	8th R_8
3	12	20.4	35.3	45.5					
4	16	17.7	30.5	39.4	46.6				
5	20	15.5	27.2	35.3	41.7	47.1			
6	24	14.5	25.0	32.3	38.2	43.3	47.9		
7	28	13.4	23.1	29.9	35.3	40.1	44.3	48.2	
8	32	12.5	21.6	28.0	33.2	37.6	41.5	45.1	48.4

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*From report of committee, J. I. Lyle, chairman, at annual meeting of the American Society of Heating and Ventilating Engineers.

The corresponding velocities for each of these readings should be determined and an average found of all of these velocities to compute the air quantity. Inasmuch as the velocity varies as the square root of the pressure, accurate results cannot be obtained by averaging the pressure readings and taking the corresponding velocity as the average.

The velocity may be determined from the velocity pressure by use of the formula

$$v = 1096.5 \sqrt{\frac{p}{w}}$$

where

v = Velocity in feet per minute;
p = Pressure in inches of water;
w = Weight of air in pounds per cubic foot under the existing conditions of temperature, barometer and humidity.

With dry air at 70 deg. and 29.92 in. barometer

$$w = 0.0749$$

whence the formula becomes

$$v = 4005 \sqrt{p}$$

With saturated air at 70 deg. and 29.92 in. barometer

$$w = 0.0735$$

and

$$v = 4046 \sqrt{p}$$

Where only approximate results are desired, for circular pipe, multiply the velocity pressure taken at the center of the pipe by 0.81 or the velocity by 0.91.

For rectangular pipe, no definite factor can be given even approximately correct which will cover the varying proportions of width to height of the cross-sectional area.

Table 2 gives corresponding velocities for various velocity pressures of dry air.

The committee recommended the pitot tube as a simple and convenient instrument for the measurement of air or gases, which, when used with the proper care and accuracy of reading, gives results with an error of less than 1½ per cent., with velocity pressures ranging from 0.1 in. upward.

TABLE 2 CORRESPONDING VELOCITY FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES

Pressure		Temperatures, Deg. F.									
In.	Oz.	50	60	70	80	100	150	200	300	500	550
0 1	0 0577	1242	1255	1266	1278	1300	1358	1413	1516	1704	1830
0 2	0 1154	1757	1776	1791	1808	1841	1921	2000	2145	2411	2590
0 25	0 1443	1965	1986	2003	2022	2059	2149	2235	2399	2696	2895
0 3	0 1730	2151	2175	2193	2214	2254	2352	2447	2626	2952	3175
0 4	0.2308	2485	2512	2533	2557	2603	2717	2827	3033	3409	3665
0.5	0 2884	2778	2808	2832	2859	2911	3038	3160	3391	3812	4095
0 6	0 3460	3043	3076	3102	3131	3188	3327	3462	3715	4175	4490
0 7	0 4037	3287	3323	3351	3383	3445	3595	3740	4013	4510	4850
0 75	0 4326	3402	3439	3468	3501	3565	3720	3870	4153	4668	5020
0 8	0 4614	3524	3552	3582	3616	3682	3843	3997	4290	4821	5185
0 9	0 5190	3728	3768	3800	3836	3906	4076	4241	4550	5114	5500
1.0	0 5768	3929	3971	4005	4043	4117	4296	4470	4796	5390	5795
1.25	0 7209	4393	4440	4478	4520	4602	4804	4997	5362	6027	6470
1 50	0 8650	4812	4864	4905	4952	5042	5262	5474	5874	6602	7100
1.75	1.0092	5197	5254	5298	5348	5446	5683	5912	6344	7131	7655
2 00	1 1535	5556	5616	5664	5718	5822	6076	6320	6783	7624	8195
2 25	1.2975	5892	5956	6007	6064	6174	6443	6704	7193	8085	8690
2 50	1 4418	6211	6278	6332	6392	6508	6792	7066	7582	8523	9150
2.75	1 5860	6514	6585	6641	6704	6827	7124	7412	7952	8938	9600
3.00	1.7300	6807	6879	6937	7003	7130	7440	7742	8307	9336	10000
4 00	2 3070	7857	7942	8010	8086	8233	8592	8940	9581	10780	11580
5 00	2 8840	8772	8867	8943	9027	9192	9593	9980	10710	12037	12900
6.00	3.4600	9623	9728	9810	9903	10083	10523	10950	11750	13203	14180

T. Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Some facts about boiler operation are discussed by the chief fireman of a large power station. An evening spent in his boiler room showed a well organized, efficient crew, contrasting in every way with the men and the methods employed in most mine boiler plants.

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After leaving Hunter on the evening of our last conversation, I strolled out to the large power house of the street-railway company to see what boiler-room practice was in vogue there. The head fireman was right on the job and every move of the men in the watch was known to him. After a little jockeying for position, so to speak, we had a sociable and interesting talk.

"How is it," I asked, sidestepping a hurrying fireman, "that your men are all attending strictly to business instead of swapping stories? How do you manage it?"

"Simplest thing in the world. In the first place, they are well paid, which counts for a whole lot. An underpaid fireman, like any other man, won't do any more than he has to in order to hold his job. My men know that if they do not do good work, there are those who will, and they also know that I have a waiting list of good men, any one of whom would be mighty glad of the chance to step into this plant."

"Of course, having mechanical stokers makes some difference in the way you handle your boilers, much different from what I have seen at most mine boiler plants, but you must have your troubles for all that."

"No doubt about it," was the reply, "but we don't tell of them. The management of a boiler plant like this," and he waved his hand toward the row of powerful water-tube boilers, Fig. 1, "is much different from what will be found at a colliery. Here we make a business of making steam to use in the form of electrical energy to transport the public. At a mine the power plant is considered a necessary evil that must be endured.

"I know all about it, for I have worked in them. If I were to take charge of such a plant today, I would insist on the firemen exercising as much care and intelligence in firing as I do in this plant. I would not allow such conditions as exist in this boiler room," and he handed me a photograph, as shown in Fig. 2.

The peak load for the night was over by this time, and we had gone into the chief fireman's office where we could talk uninterruptedly and burn up a few local-brand of cigars. After we were comfortably seated, I said: "Now, if you were in charge of a hand-firing mine plant, how would you work the men to obtain the best results?"

"I would insist upon the men following a few simple rules, such as experience has determined to be the best. First of all, the men would be required to fire evenly and at regular intervals, firing approximately the same amount of coal at each charge. If the fires are kept in proper condition, not more than five shovelfuls of coal will be required at each firing. This kind of firing would force the men to put the green coal on the thin places only.

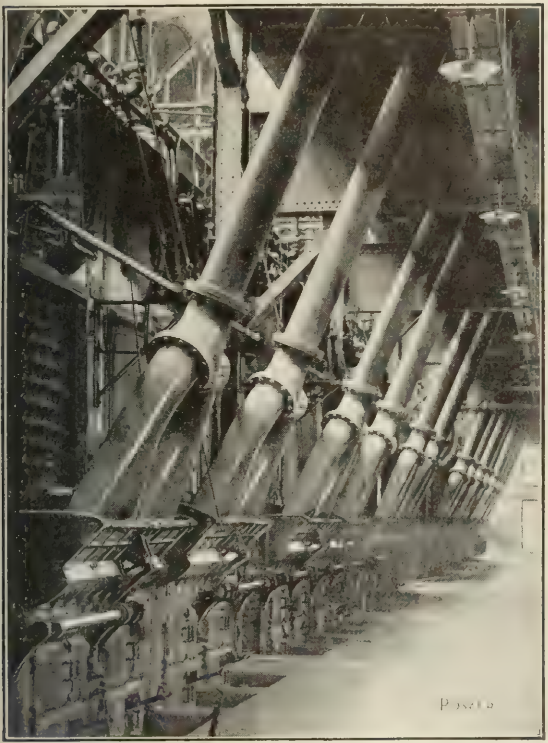

Fig. 1. A Row of Powerful Boilers

"Where most firemen intentionally waste fuel is to pile the coal all over the fire, regardless of its need. The idea is to get a resting spell between firings, economy be blown!

"Another thing is to keep the fires clean and bright. This cannot be done if the shaking grates are not operated. At certain periods fires should be thoroughly cleaned the same as if stationary grates were used. Furthermore, a fire cannot be kept even if huge chunks of coal are thrown into the furnace just because the men won't take the trouble to break them up; they would have to do so, if I were in charge."

"Would such firemen do their work properly if they received a suitable wage instead of a boy's pay?" I asked, at the same time noting the wide-awake, alert actions of the men out in the boiler room.

"Probably some of them would, and then there are a few who have become so used to the haphazard method of stoking that it would be most difficult to get them to adopt new methods without a struggle, which wouldn't be worth while.

"It is difficult to make them understand that the draft and air supply must be regulated to suit the working conditions and so if the demand for steam decreases, the safety valves blow before much, if any, attention is given to the draft. Then the ashpit doors are kicked shut, if the accumulation of coal on the floor will permit. This accomplished, they sit down surrounded by dust and dirt until the steam pressure has dropped, when the ashpit doors are kicked open, and the fires are vigorously barred to quickly get the boiler steaming again. A fire should never be barred unless it is absolutely necessary.

"If such firemen would use their heads they would watch the condition of the fires and the steam pressure, because the latter is dependent upon the former. If the steam pressure rises or falls it is because a change of temperature has occurred in the furnace. The steam should be maintained at a constant pressure and the feed water at a uniform level, not out of sight at one time and above the third gage at others."

"I have noticed," said I, stroking the back of the cat that was industriously rubbing back and forth against the leg of my chair, "that in many boiler plants the settings are badly cracked and the furnace doors are cracked and warped. In some cases, the front-tube doors have been corroded through the metal and water, leaking from the header caps, I suppose, was running down the boiler front." (Fig. 3.)

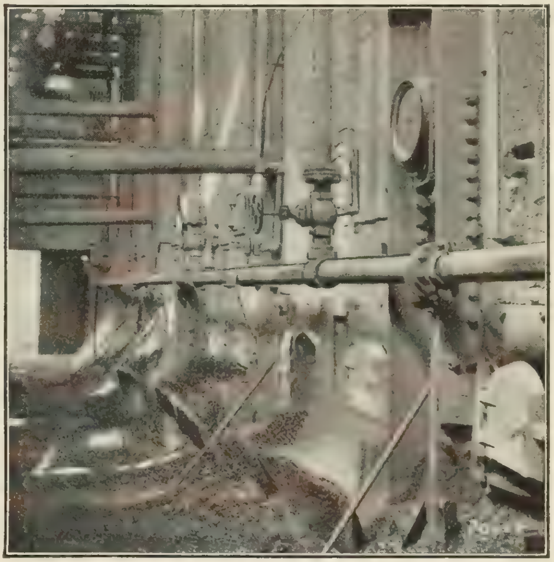

Fig. 2. No Attempt Had Been Made to Keep the Floor Clear of Coal

"Well, that goes to show that the men were neglecting matters. Boiler settings, fronts and doors should be kept in order. If cracks exist in the setting, air will leak into the combustion chamber where it is not wanted. It cools the gases, and does no good."

"From what I have seen and heard, I should think that it would be a paying investment for some of these mine operators to hire a first-class man to take charge of their boilers—one who would make it his business to keep the men up to a standard and the boilers in condition. Then the water in many instances is bad, so that scale and its attending troubles must be met.

"I knew of one superintendent, a bright chap, who used a simple means of keeping scale out of his boiler, one that most engineers would have condemned, but he claimed it worked all right, and I have seen his scheme worked out.

"This man had 1200 hp. in water-tube boilers and discovered through an accident that black strap oil, such as is used to oil mine-car wheels, would prevent scale from adhering to the boiler tubes.

"It happened this way: One of the men, after cleaning a boiler, accidentally spilled some of this black strap oil into the tubes. There was no time to remove it, and the boiler was put into service. When it was again cut out for cleaning, it was found that the tubes were clean. This caused the superintendent some surprise, who, after a little speculating, decided it was due to the oil that had been spilled in the boiler at the last cleaning day."

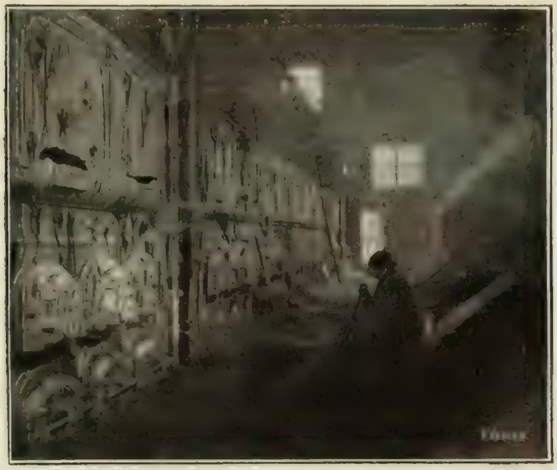

FIG. 3. THE TUBE DOORS OF THE BOILERS ARE CORRODED AND THE HEADER CAPS LEAKING

"I supposed oil was a dangerous thing to put into a boiler. There have been a good many dollars spent in oil separators just to keep it out of the exhaust steam.

"Yes, I know, but this superintendent has used oil in the boilers of every plant he has had since his discovery and he has found that it did the work in every instance.

A 10-gal. tank was placed above the heater. The tank was piped to a lubricator sight-glass, the bottom outlet of which was connected to the suction pipe from the heater to the boiler-feed pump. The sight-feed was set so that half a pint of oil would feed to the boilers in 24 hr. He told me that he now cleans 12 water-tube boilers in eight days, whereas if formerly required three or four days to clean one."

"I'll bet that man had a well kept plant, for from what you have told me he is a man who thinks and acts."

"Right you are," answered the fireman, arising to bid me good-night, as I opened the office door; "he is one man who knows what is going on."

As I passed through the boiler room on my way out, I noticed that the men were just as alert and attending as strictly to their work as they had been when I entered the plant, which emphasized the fact, to me at least, that a well organized boiler-room force is a paying investment, and that a boiler room left to shift for itself and attended by men who care nothing about its economic operation is a losing proposition, no matter how poorly the men may be paid.

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The Aftermath

In February, 1905, Congress passed an act, granting to the Keokuk & Hamilton Water Power Co. rights to construct and maintain, for the improvement of navigation and the development of power, a dam across the Mississippi River from Keokuk, Iowa, to Hamilton, Ill. Congress was induced to accord this privilege by representations that the building of such a dam would greatly aid in the navigation of the river, that the Government would save a large sum in the annual cost of maintenance and operation of the lock at the Des Moines Rapids, and that the development of waterpower there would be of great benefit, not only to the immediate neighborhood, but to the commercial and manufacturing interests of the country.

Now Congressman Rainey, of Illinois, proposes:

Whereas the authority or franchise mentioned above was assigned to the Mississippi River Power Co.; and whereas the Missisippi River Power Co. has now completed the dam across the river; and whereas the steamboat companies navigating the said river claim that the dam is a hindrance instead of a help to navigation, and that their boats have to wait until the power company lets down enough water to float them; and whereas the Mississippi River Power Co. and its subsidiary companies are now engaged in buying up electric-light plants within its sphere of operations in the States of Illinois, Missouri and Iowa, paying, therefor, in many cases, much more than said properties are worth, and thereafter rendering less efficient service than was formerly rendered, demanding the same or greater compensation therefor; and whereas it is claimed that the development of water power at the said dam has not been of great benefit to the immediate neighborhood, or to the commercial and manufacturing interests of the country on account of the poor service rendered by the Mississippi River Power Co. and its allied and subsidiary companies, and on account of the excessive compensation demanded by such company and its allied and subsidiary companies; and whereas in defiance of law, and without the permission of the Congress, the said Mississippi River Power Co., or some company operating under its control, has built a bridge across the river, further obstructing navigation; and whereas Congress got nothing from the company for granting the privilege, other than the promise of said company to so construct and operate the dam and locks as to greatly aid navigation, and as to be of great benefit to the immediate neighborhood and to the commercial and manufacturing interests of the country, but reserved the right of repeal:

BE IT RESOLVED, that the committee on Interstate and Foreign Commerce of the House of Representatives be, and the same hereby is, directed to inquire into the same, send for books, papers and documents, summon witnesses, take testimony, with a view to determining whether or not said act ought to be repealed, or whether or not said act ought to be altered or amended so as to provide for an adequate compensation to the Government for the valuable privilege granted.

Editorials

New Jersey's Good Sense

New Jersey should rejoice that she is not to be burdened with a recently proposed boiler-inspection law, as the bill failed to pass in the legislature. It did not provide for a standard of design or installation; it did not make it necessary to determine by civil-service examination the qualifications of those who might be appointed inspectors; it made no exception of boilers under insurance inspection.

New Jersey needs a boiler-inspection law, but she does not need or want a law that does not equal the best. When New Jersey or any other state seriously considers having boiler laws, the bill should authorize the creation of a board of boiler rules. Let the latter adopt the Massachusetts rules, which will have the support of manufacturers of boilers, boiler-insurance companies, owners and engineers. These rules have been so changed and revised that now they meet all conditions, particularly those that are common to every state. Ohio and Detroit, and one or more of the Canadian cities, have adopted these rules and we understand that the Phillipines Commission recommends them.

There is every reason why boiler laws should be uniform throughout the country and none why they should not.

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Smoke Means Waste

On the text over the cartoon this week we could preach quite a sermon, but we have referred to it so often editorially and the picture in itself is so eloquent that it scarcely seems needful to add more. There is one phase of the subject, however, and in a measure it is the keynote of this week's illustration, that does deserve emphasis. This is the fact that although "smoke means waste" is well known to so many, it is usually those who are most concerned that fail to appreciate it. They are inclined to think that the only reason for keeping their stacks from smoking is to avoid the complaints of the neighbors that they are maintaining a nuisance. Good and sufficient as is this reason, there is another that, even in the absence of this one, would be excuse enough for the exercise of every endeavor to stop smoke and that is, reverting again to the text, that "smoke means waste."

Some are indifferent to the black soot they scatter and are incensed at the ordinances directed against them because they fancy that it will cost them money to prevent smoke. For all the world like children who cannot see that the restrictions imposed upon them by their parents are generally for their own good, these short-sighted owners of smoking chimneys think that the measures taken to have the smoke stopped are in the interests of those who have smoke-abating devices to sell, if not deliberate persecution, whereas, if they but knew it, their own best interests will be served by cutting out this waste of money that is indicated wherever a stack is emitting black smoke.

Where is the plant owner who would not take immediate steps to stop it if he learned that his coal pile was being robbed? Would he wait for the city authorities to compel him to put an end to the thieving? Yet substantially he is doing that very thing when he continues to operate a plant that is discharging unnecessary volumes of dense smoke. The inexcusable part of it is that he himself is the robber and hence has it easily in his power to stop the theft.

This is not to say that all smoke can be prevented. No one who has studied the problem would even maintain that every bit of black smoke can be avoided, but under proper conditions and normal operation there should be very little of the time when an observer standing outside could tell from the appearance of the top of a stack that a plant is in operation.

For the benefit of any who may not see the analogy between a robbed coal pile and a smoking chimney, it may be briefly and simply explained. The visible part in smoke is nearly all carbon, either as soot or cinder, and carbon is the principal combustible part of coal, i.e., the useful part, the part capable of yielding heat. Carbon completely burned forms an invisible gas, carbon dioxide, therefore, whenever the gases from a stack show black they contain carbon which indicates that complete combustion has not taken place in the boiler furnace. In other words, all of the available heat in the coal has not been realized. It is the same as though the corresponding part of the coal fed into the furnace had been thrown away, for, although it has passed through the furnace, it has been thrown away up the stack beyond recovery. Is this, then, so very different from robbing the coal pile?

The owner who, through ignorance, allows conditions to exist which are not favorable to the most economical operation of his boiler furnaces—and black smoke from the chimney mouth is the unmistakable index of such conditions—although he is unwittingly robbing himself, is nevertheless stealing from his own coal pile. When he raves at his coal bill, like the man in the picture, he should vent his ire on himself, if he only knew it, and take kindly to the suggestions of the smoke inspector when the latter calls to remind him of his offending chimney. The inspector is a friend indeed if he can show him how to save the dollars that are escaping in the smoke.

It is not the purpose herein to discuss the various means for reducing smoke and thereby saving money. The situation in any individual plant calls for specific treatment. It is the part of the expert to diagnose the trouble and prescribe the remedies. Power has shown in the past, and will continue to show, what are the principles governing smokeless combustion and what means have been successful in certain installations. How to get rid of the smoke, however, is not our main concern at present. What seems to be the most immediate difficulty is to get the owner properly aroused to the truth that "smoke means waste."

Temperature Variations in the Steam Plant

How many engineers have ever taken the trouble to ascertain the approximate difference in the temperature of steam and water in making a cycle from the boiler, through the various power-plant units and back to the boiler? Probably not many, yet the subject is of interest, and should be known to every power plant operator.

Every steam plant is different, because the size of generating units, length of piping and design, and efficiency of the pipe covering will have a marked effect on the reduction of heat in the steam in doing work and from condensation and radiation.

From the moment combustion of fuel in the furnace takes place, transfer of heat, given up by the coal to the water in the boiler, occurs. The average temperature of a boiler furnace is about twenty-five hundred degrees, and the temperature of the furnace gases escaping to the chimney is generally between four hundred and six hundred degrees. The difference between furnace and chimney temperatures represent the heat absorbed by the brick boiler setting and by the water in the boiler. The greatest drop in temperature occurs between the furnace and second pass of a water-tube boiler; the drop is much less in the following passes.

When steam is admitted to a pipe system the temperature and pressure drop, due to radiation and pipe friction. The temperature of the steam at 164 lb., absolute, in the steam space of the boiler is, say, three hundred and sixty-six degrees. In the average steam plant the drop in temperature will be at least two degrees. Entering the high-pressure cylinder the temperature of the steam, in doing work, is reduced to approximately two hundred and fifty-six degrees, and exhausts to the low-pressure cylinder at two hundred and forty-four degrees, when the temperature is again reduced, this time to one hundred and ninety degrees. It passes to the condenser at one hundred and twenty-four degrees, a total drop of two hundred and forty-two degrees. A further drop in temperature occurs in the condenser, where the steam is condensed to about one hundred degrees at which temperature it passes to the hotwell in the form of water.

At this point of the cycle the exhaust steam of the auxiliaries is used to bring the hotwell water to a higher temperature before returning it to the boiler as feed water. If the steam auxiliaries use steam at boiler pressure its temperature will be three hundred and sixty-four degrees and will exhaust to the feed-water heater at about two hundred and nineteen degrees, which will raise the hotwell water to about two hundred degrees in passing through the heater. At this temperature it is discharged back to the boiler at one hundred and sixty-six degrees less than the original temperature of the steam supplied to the engine.

If feed water is taken from the city main or a source of supply other than the hotwell at, say, seventy degrees, the exhaust steam from the auxiliaries will be used to raise the temperature, but the water would go to the boiler at a lower temperature than if hotwell water were used with the same amount of exhaust steam.

The foregoing are approximate figures that would obtain in the average steam plant, with water-tube boilers and compound-condensing engines, using saturated steam at absolute pressure. The insert accompanying this issue of POWER shows such an installation in section with the temperature of the steam and water designated at different points in the piping and steam units.

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Taking the Floor

Scott and his brave party trod over frozen snows and icy wastes, and died of starvation and exposure in their efforts to add to the store of human knowledge. Daring men have ascended to dizzy heights and fallen to their deaths to gain the experience which makes flight by heavier-than-air craft the success it now is. To add to the recorded knowledge of botany, Humboldt climbed mountain peaks until blood flowed from his nostrils, and, faint in the rarified air, he was forced to descend.

These men and many others have done these things that they might give to the world a better understanding of the planet which is our abode. Their reward was honor, simply honor. There was no salary attached to the efforts made.

How weak, how small, are those who, feeling the need for more knowledge of their craft, surrounded by every means for obtaining that knowledge, content themselves to plod in ignorance for fear they will expose themselves to criticism for asking questions about that which they wish to know. These men must blaze no new trails; others have done that for them. The path is lighted by recorded knowledge and the hand of Opportunity beckons them on to partake of the fruits of accomplishment.

In every power-plant engineers' organization, there are men who want to know more, but are reluctant to seek from those of their fellows who are only too glad to give. Enough of these reluctants in an organization will soon ruin it. It will die from non-use and they themselves are the sufferers. It is the men who ask, who seek to know, that keep an organization alive by their questions and participation in discussions. The man who is afraid to take the floor to ask questions starves himself of information that his mental appetite craves.

Let those who realize their weakness in this direction make better use of the opportunities that are presented by every discussion on the meeting room floor. This season is but half gone and many more are to come.

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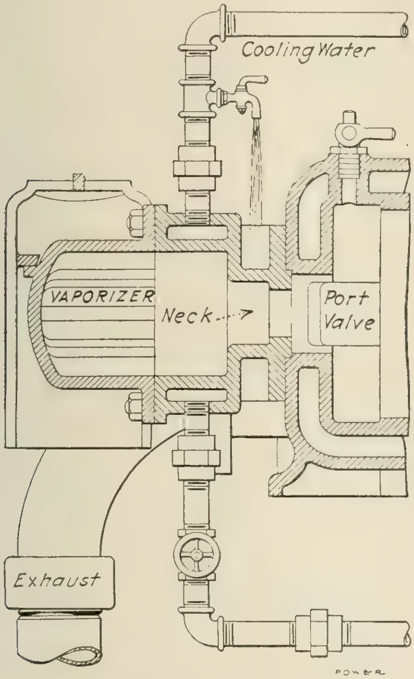
The movement in favor of the passage of uniform laws relating to the construction and inspection of steam boilers by the legislatures of the various states is being taken up by the locomotive companies, as well as by the manufacturers of boilers for stationary purposes. It has also attracted some attention from the Association for Uniform State Laws, and is likely to be brought forward at the next congress of the association. The American Society of Mechanical Engineers has a committee upon uniform boiler specifications which is also interested in this phase of the subject. With such backing, this legislation which POWER has been urging for the past quarter of a century should go rapidly forward.

Time's up, gentlemen, on that test of the Hall of Records Building in New York. What's the verdict, Isolated or Edison?

Correspondence

Prevents Preignition in Oil Engine

The illustration, Fig. 1, shows the manner of changing the circulating-water piping on a crude-oil engine of the vaporizing type so as to prevent preignition caused by an overheated part. As the interior cooling did not extend to this point a tee was inserted in the discharge pipes of the outgoing circulating-water line and a small pipe inserted, having a small valve to enable one to regulate the amount of water flowing. This pipe discharged the water on the outside of the small neck of the vaporizer, which would become so overheated on heavy loads, that at times the casting would crack at this point.



How the Neck Was Cooled

In this type of engine the fuel is injected on the suction stroke and vaporized by heat and compression, and at the proper pressure and temperature the charge will fire by coming in contact with the hot cup which is not water-jacketed. The indicator diagram, Fig. 2, shows the engine working under full load with the water flowing upon the neck to keep the engine in its normal condition, while Fig. 3, shows the engine working on a lighter load, and having the cooling water cut off from the neck. In this condition preignition occurs and forms the loop in the diagram.

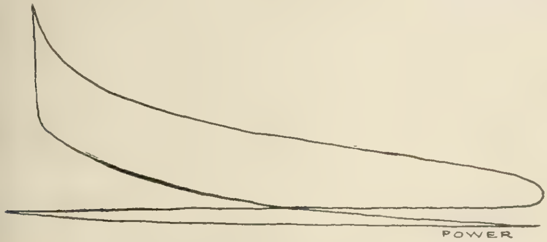


Fig. 2. With Water Applied to Neck

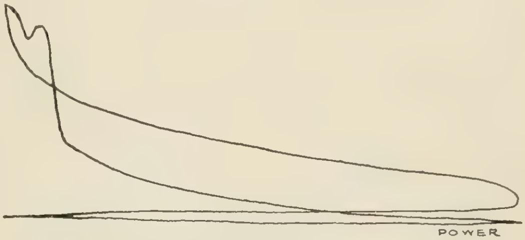


Fig. 3. With Water Not Applied to Neck

C. R. McGahey.

Baltimore, Md.

Peculiar Pump Trouble

In a plant where I was engineer there was a pump of the single-acting type for supplying cooling water to an ammonia condenser. This pump worked smoothly and I did not pay much attention to it for the first few days, but finally my attention was called to it by the manner in which the water acted in the jackets of an upright ice machine.

Every little while those jackets received a lot of air and the water would splash over the machine. As this had been a common occurrence, I was told not to bother about it, but I wanted to know where so much air was coming from, particularly as there was no chance for the water in the reservoir to get below the suction line. Finally I discovered a ¼-in. pipe tapped into the suction line close to the pump and ending in the basin-like frame of the pump. There was a valve on this line which appeared to be leaking badly. I took the bonnet off and found that the end of the stem had been cut off. I put in a new valve and upon closing it was surprised when the pump began kicking and pounding. With the valve open again the pump ran as smoothly as ever. I tried closing that valve fully 20 times during the day and the result was always the same. I was told that air must be admitted to the suction to keep the pump going.

At the first opportunity I examined the valves and packing in the water end. They looked all right, but a few days afterward I put in a new set of valves and springs and also new plunger packing. Still the trouble remained, and was not located until the pump was taken apart.

At some time a new brass sleeve had been fitted into the water cylinder and the man who did the job had taken his measurement from the frame-end head to the outside end of the barrel instead of just the length of the barrel. He did not figure how the water was to get into the frame end of the water cylinder from the suction chamber. There was a small opening, but not enough to admit the water fast enough, so that air was used to fill in. The sleeve was badly worn and as it would not last much longer I took it out and ran the pump without a brass lining. To do this two large washers were made to increase the piston diameter so that the packing would hold. The result was a smooth running pump that did not have to be filled with air.

A. G. SOLOMON.

Chicago. Ill.

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Circuit-Breaker-Bell Alarm

Due to the scattered arrangement of our power equipment and to various duties of the engineer calling him away from the engine room, it became necessary to install an alarm system of some kind which would call the attendant to the traveling-crane feeder panel whenever the circuit-breaker was tripped. We, therefore, devised the arrangement shown.

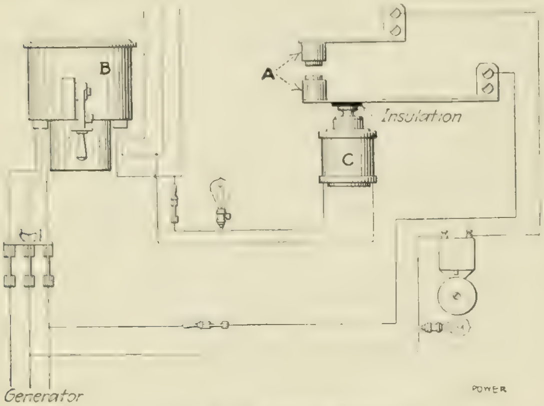

DIAGRAM OF ALARM SYSTEM

An old 240-volt call bell which had previously been used as a ground detector was repaired and mounted in a convenient place where it could be easily heard from either of the two engine rooms or the fire room. It was connected to the generator side of the oil switch through a 120-volt lamp and carbon-tipped contacts *A*. These contacts were made by inserting small pieces of arc-light carbon into the brass terminal caps of an old 30-amp. cartridge fuse, leaving about 1/8 in. of the carbon projecting. These caps were then soldered to pieces of thin spring brass and mounted on the wall near the oil switch *B* so that the carbons were about 1/2 in. apart. A small shunt-trip coil *C* taken from a discarded circuit-breaker was mounted, as shown, and connected through a 240-volt lamp to the line side of the oil switch. When the coil is energized, as when the main circuit is closed, the magnet plunger is drawn down and the spring of the brass mounting of the lower contact holds the contacts apart, thus breaking the bell circuit. When for any reason the oil switch is tripped, the shunt trip coil is no longer energized and the plunger is expelled by a spring, forcing the carbon contacts together against the slight spring of the lower contact mounting, thus closing the alarm circuit which lights the 120-volt lamp and rings the call bell.

M. E. MERRIMAN.

Boonton, N. J.

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Cost of Power from Hydro-Electric Stations

In the issue of Feb. 10, page 204, Ralph E. Somers says that the cost of a horsepower for a year of 3600 hr. would be some $20. This would be simply the charge for current. As the plant would have to supply its own switchboard, wiring, motors, controllers, belts, etc., upon the cost of which interest, depreciation and taxes must be charged, and would be at some expense for attendance and supplies, the total cost per horsepower-year, comparable with that generated by a steam plant at the mill, would be somewhat in excess of the $20 quoted, would it not?

S. B. STEBBINS.

Atlanta, Ga.

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Removing Frost from Direct-Expansion Coils

The idea is good in Mr. Thurston's article under the above title, in the Jan. 6 issue; it puts me in mind of a brewery refrigerating plant in which I once worked. The plant was large and equipped with reserve machinery so that a compressor could be started to take the place of one out of order, as continuous operation was necessary. Now and then, when the ice on the coils became so heavy that the valves could not be closed, the men knocked it off with hammers and chisels. This was bad practice; Mr. Thurston's hot-gas line would have been better.

Eventually, a different plan was adopted. The night engineer was told to close one of the valves on the liquid line controlling three rooms. The following morning the ice around the pipes was soft and easy to knock off. After all the ice had been removed, the ammonia was turned on again. The following night another valve controlling three other rooms was closed, and the valve that had been turned off the night before was again closed. The light coating of ice on the coils was completely melted off in two hours. By this time the temperature in the six rooms had not risen more than 1 deg. R. The ammonia valve controlling the first three rooms was then opened and the thermometer read 1½ deg. R. lower in the morning in these rooms than it did when the heavy ice was on the coils and the ammonia on all night.

After the heavy ice had been knocked off all the coils in succession, we shut down every night until the light coating of ice, caused by about 22 hr. run, was melted off. We could even afford to shut down in the hottest weather and still have the rooms 1 to 2 deg. R. lower in the morning than they had been under the old method of operating. Some brine was used for cooling beer, and this went up 2 to 3 deg. R. in the two hours the plant was shut down, but by morning the temperature was back to normal. In storage houses requiring a constant temperature, Mr. Thurston's method could not be used for removing the ice, but would be convenient for pumping out condenser sections separately.

William L. Keil.

Philadelphia, Penn.

Mr. Thurston's article appears rather impracticable to me. It is certain that ammonia gas at 200 deg. will take the frost off coils if it reaches them at anywhere near this temperature, but will the hot gas go into the coils hot enough to do any good? I have heard of this system being used, but I have never seen it operate satisfactorily. In my opinion, half a dozen laborers, directed by an engineer, will do this work better and in much less time.

The frost can be melted free from the coils by shutting the suction valve and leaving the expansion valve open, so that the coil will partially fill with liquid. This method, however, is not to be recommended. The chance of starting leaks in the flanges and other places is great, with the resultant loss of ammonia and encountering other disagreeable features. Care must also be taken in again getting the liquid ammonia out of the coil and through the compressor without doing damage. While all this is going on the ice machine is doing little, if any, good to the other rooms which require cooling.

Expansion valves are usually ½ in. in diameter and there is always some ½-in. pipe between the expansion valve and the coil of 2-in. pipe. The hot gas will cool considerably while traveling from the ammonia condenser to the ½-in. expansion valve. Then in passing through a few feet of ½-in. pipe and through a ½-in. valve in the cold room, more heat will be lost. Then the gas will lose a large part of its remaining heat when it enters the 2-in. coil, due to the expansion at this point. The frost on the coil and the low temperature of the room will finish the job, and the hot gas from the condenser will be cool liquid before any frost drops off.

I once saw a coil cleaned by someone who accidentally shut the suction valve and let the expansion valve stay open until the coil was full of liquid and must have had condenser pressure on it. In that case a gasket was blown out of a 2-in. flange and a lot of ammonia was lost. A gang of men was driven out by the fumes and the work was delayed several hours.

In another case, the heavy frost fell off of about 60 ft. of 2-in. pipe in the center of a coil 1000 ft. long. It was found that the pipe had been blocked nearly solid by a slug of solder which had entered the pipe when the flanges were sweated on.

Both of these jobs were accidental, but they are enough to make me decide that it is a poor way of getting results. Clean the frosted coils with scrapers, and the compressor can be kept in operation on some other part of the plant at the same time.

A. G. Solomon.

Chicago, Ill.

Mr. Solomon's criticism is not quite justified, as thawing off the refrigerator coils by means of the hot vapor from the ammonia compressor can be satisfactorily performed. It is only necessary to shut off the suction valve and allow the hot vapor to enter the coils. By the time the pressure in the coils rises sufficiently to cool and liquefy the hot gases, much thawing can be done; in fact, more ice can be thawed off in this way than with the liquid entering from the expansion valve.

In all these thawing-off systems, it is necessary, when starting up the coil again, to be careful to open the suction valve slowly, so that the refrigerating machine will not be flooded with liquid and perhaps be damaged.

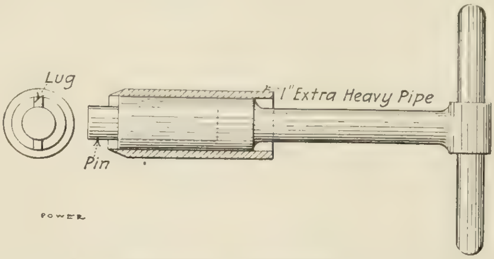
Fred Ophuls.

New York City.

*

Tool for Removing Condenser-Tube Glands

The accompanying drawing is of a tool used for removing condenser-tube packing glands. The body is bored to the size of the inside diameter of the tube. A pin is fitted in the bore with the end projecting so as to enter the tube about ¾ in. A piece of 1-in. extra-heavy pipe is bored out and slipped over the tool and packing gland to prevent the slot in the latter from breaking out.



Tube for Removing Condenser-Tube Glands

I made a tool of this design for taking out old glands, and find it better than the common gland tool. If the lugs break off the tool, it is only necessary to pull out the pin and file or saw new lugs. I case-harden the lugs to give additional strength.

F. R. Lewis.

Peoria, Ill.

*

Throwing Oil

On an old-style dynamo having no oil-throwing device inclosed in the bearings, a brass plate about $\frac{3}{16}$ in. thick was affixed to the end of the commutator and insulated from it by mica. The idea was to throw off any oil which would creep along the shaft. Sometimes the machine sparked and sometimes it did not. However, I decided to investigate.

Upon removing this brass plate I found that the oil creeping along the shaft had also crept between the layers of mica and spoiled the insulation. At two or three places a small hole had been burned through the mica, which allowed a spark to start. I put a piece of thin rubber packing in the place of the mica and had no further trouble.

If there is a fairly large collar on a high-speed armature shaft it is a first-class spraying device, and with the suction of the air through the armature, the coils will soon become soaked with oil. The easiest way to obviate this is to put a small sheet-metal oil guard over the collar; this will catch the spray and allow it to drain to the bottom of the bearing.

W. Burns.

Govan, Scotland.

Inquiries of General Interest

Shifting Brushes of a Generator—What is the effect of shifting the brushes of a generator from the neutral position?

C. B.

If shifted too far, sparking will result and the voltage will be reduced.

Current Density with Carbon Brushes—How much current may safely be carried per square inch of brush contact with carbon brushes on a small 115-volt generator?

J. F. B.

With the commutator true and smooth and brushes ground to a good fit, it is considered by many that 35 amp. per sq.in. of brush contact is all that should be allowed for carbon brushes.

Negative Lap with Double Eccentric Corliss Valve Gear—Why are the steam valves of a double eccentric Corliss engine given a negative lap?

F. C. H.

The range of cutoff for the Corliss valve gear is from the beginning of the stroke to half stroke or less. When a longer cutoff is desired the wristplate must be moved by an eccentric with negative advance and the steam valves have a clearance instead of lap.

Foot-Pound Resistance of Steam Fitting—In testing the strength of close nipples when inserted in a steam fitting what is meant by "resistance in foot-pounds?"

W. R.

Resistance in foot-pounds refers to the moment or leverage resisted by the fitting, expressed as a product of force or test weight in pounds multiplied by its lever arm or perpendicular distance in feet of the action line of the force from that point of the fitting under consideration.

Moisture in Steam—What percentage of moisture is contained in steam discharged from boilers in ordinary use?

H. L. R.

When horizontal return-tubular boilers of average proportions or water-tube boilers having drums that afford ample disengagement surface are fed with water free from ingredients which cause foaming, and the boilers are not driven beyond their normal capacities, nor the water level carried too high, then the steam discharged will usually contain not more than about 2 per cent. of moisture.

Rotary Transformer and Motor-Generator—What is the difference between a rotary transformer and a motor-generator?

L. N.

Both serve the same purpose—to convert direct into alternating current, or vice versa. A motor-generator set is a motor and a generator each complete in itself with their shafts directly coupled, while in a rotary transformer, or rotary converter, the alternating and direct-current windings are in the same machine.

Advantages of Suspended Boiler—What are the advantages of suspending horizontal-return tubular boilers as compared with supporting them on the side walls of brick settings?

C. D.

The setting of a suspended boiler can usually be arranged to take up less space; the brick work and boiler shell may expand and contract independently; brick work may be removed and repaired without endangering the supports of the boiler; the walls are less likely to settle or crack; and equalizing levers may be employed for sustaining desired proportions of weight at the different points of suspension.

Kerosene in Boilers—What are the objections to the use of kerosene in boilers for preventing boiler scale?

C. N.

The principal objections are that it is likely to cause leaking of calked joints, around rivets and of the expanded joints of tubes. Leaks thus induced are difficult to stop. Further objections are that, with some feed waters, the use of kerosene is accompanied by oily deposits which are likely to result in overheating or burning of the material of a boiler and that the volatile oil carried over with the steam causes leaking of steam-pipe joints and softening and leaking of packings.

Consumption of Gasoline—What amount of gasoline would be required per hour to run a 25 hp. engine loaded two-thirds of its capacity?

C. H. L.

It is usual to consider the consumption of a gasoline engine as one pint of gasoline per horsepower-hour when the engine is in good condition and running at full load. The fuel consumption is slightly greater when running at lighter loads. Assuming, then, that the gasoline consumption at two-thirds load would be 1.2 pints per horsepower-hour, the total hourly consumption would be $1.2 \times 0.66 \times 25 = 20$ pints per hour.

Obtaining Shorter Cutoff—How can the cutoff of a Corliss engine be shortened?

R. T. R.

The governor automatically adjusts the cutoff to the mean effective pressure required for maintaining the speed, and as, for a given horsepower developed, the mean effective pressure is inversely as the speed, the governor will shorten the cutoff if the speed of the engine is increased, but with the same load and same speed the governor will automatically adjust the valve gear to a point of shorter cutoff for an increase of the initial pressure or a decrease of the back pressure on the piston.

Large and Small Calorie—What is the distinction between "large calorie" and "small calorie"?

L. B. B.

The large calorie is the French thermal unit and is that quantity of heat required to raise the temperature of one kilogram of pure water from 4 deg. C. to 5 deg. C. It is the usual "calorie" of engineering, being equal to 3.968 B.t.u. The small calorie is the thermal unit of physicists, being the quantity of heat required to raise the temperature of 1 gram of pure water from 4 deg. C. to 5 deg. C.; hence the small calorie is the one-thousandths part of the calorie generally used in engineering computations.

Equal Vacuum for Different Barometric Readings—With a barometric reading of 27.4 in., how many inches of vacuum would have to be obtained for the same condenser pressure as with 26 in. of vacuum at sea level?

H. B. F.

For the same temperature of atmosphere surrounding the mercury gage and barometer in each case and assuming the atmosphere at sea level to have a barometric pressure of 30 in., then a vacuum gage reading of 26 in. at sea level would be 30 in. — 26 in. = 4 in. of mercury column pressure for the given gage temperature; hence for a barometric reading of 27.4 in. the same absolute pressure would exist when the vacuum gage showed 27.4 — 4 = 23.4 in. of vacuum.

Wattless Current—What is meant by wattless current? How may it be detected, and does wattless current represent wasted energy?

H. L. M.

In an alternating-current circuit containing inductive resistance, counter-electromotive force is set up which opposes the flow of current. This causes the maximum values of the current and voltage to occur at different times, in other words, the current is said to lag behind the voltage. The total current is not effective. The ineffective part is called wattless and, expressed graphically, the component of the current at 90 deg. to the electromotive force is wattless, as it can do no work. It may be detected by a power-factor meter or by noting the difference between the wattmeter reading and the product of the voltmeter and ammeter readings.

Wattless current does not represent wasted energy, but it leads the line and limits the current-carrying capacity.

Engineers' Study Course

The Slide Rule--II

Last Lesson's Answers

1. Set the right-hand "1" of the C-scale on 93 of *D;* under 17 of *C* is found 158. By inspection it is seen that 0.0093 is very close to 0.01 and $^1/_{100}$ of 17,000 would be 170, so the answer will have three whole-number places, or

$$17{,}000 \times 0.0093 = 158$$

2. Set the hair line of the runner on 316 of *D.* Slide *C* until 273 (the last figure, "3," will be 1½ of the smallest divisions) is under the hair line. The answer under "1" of *C* is 1157 (the last figure is estimated) on *D.* By inspection, 273 into 0.0316 will require three ciphers after the decimal, so the answer is

$$\frac{0.0316}{273} = 0.0001157$$

3. In problems of this sort generally it is better to take a division first then multiplication and so on alternating. It reduces the number of resettings of the slide, as will be explained later, although it will not in this particular case. Set the hair line on 605 (the first small division after "6") of *D.* Move slide until 437 (the "7" is estimated as ⅔ of the second smallest division after 43) on *C* is under the hair line. Under "1" of *C* is 1382 on *D* which is the quotient and must still be multiplied by 921. The latter on *C* is off the scale to the right, so the slide must be shifted end for end by first placing the hair line over the left-hand "1" of *C;* then bringing the right-hand "1" of *C* under the hair line. Now slide the hair line to 921 on *C* (the "1" is estimated) and under the line on *D* is the answer 1275 and it is clear that it is a whole number and there is no decimal point to be placed.

4. The formula required is the familiar

$$hp. = \frac{PLAN}{33{,}000}$$

The *P* is given 26.7 lb. The length of stroke is 10 in. or $\frac{10}{12}$ ft. = *L.* The area is $10^2 \times \frac{\pi}{4} = 10 \times 10 \times 0.7854 = A$ and the number of strokes per minute is twice the number of revolutions per minute, or $346 \times 2 = N$. Then the equation is

$$hp. = \frac{26.7 \times 10 \times 10 \times 10 \times 0.7854 \times 346 \times 2}{33{,}000 \times 12}$$

Quite a little canceling is possible as a short cut; the three "10's" into the "33,000" the "2" into the "12" and the "6" left into 0.7854; so that the equation before using the rule at all can be simplified to

$$hp. = \frac{26.7 \times 0.1309 \times 346}{33}$$

Set the hair line on 26.7 *D;* bring 33 of *C* under the line; move the line to 1309 of *C;* bring left-hand "1" of *C* under the line; move the line to 346 on *C.* The answer is now under the line on *D,* or 366. A 10x10-in. engine must be more than 3 hp. and less than 300 so the answer is 36.6 hp.

5. If the coal consumption is 10 lb. per sq.ft. of grate area per hour, it is 10x27 lb. per hour, and per square foot of heating surface

$$\frac{10 \times 27}{920} = \frac{27}{92} = 0.293\ lb.$$

The problem could also be stated as an inverse proportion

$$920 : 27 : : 10 : x$$

and solved as later explained for proportions.

It is to be noticed that it was not necessary to carry the decimal point in mind through any of the problems.

The Slide Rule Continued

To solve 117 × 57 ÷ 45, one can multiply 117 by 57, and make a resetting to divide by 45. It is, however, much shorter to set the hair line on 117 of *D* and bring 45 of *C* opposite it, then the quotient 2.6 is found on *D* under the "1" of *C.* Without resetting the slide, move the hair line to 57 of *C* and read the final product of *D,* i.e., 148.2. It is impossible to read the rule so exactly as to know that the product is 148.1, 148.2 or 148.3, but the product of two numbers ending in a 6 and a 7 respectively must end in a 2, so that this determines the fourth figure. The application of this principle will enable any product of two 2-figure numbers to be read with absolute precision on the rule. Thus 83 × 94, it is impossible to read much closer than 780 on the rule, but mentally saying 3 × 4 = 12 enables us to give all four figures 7802. The fewer settings to be made by the rule, the greater the accuracy.

Proportions are readily solved on the slide rule. For instance, 74 : 67 : : 8.2 : x. A simple rule is: "Set the first on the second; under the third is found the fourth. For example, set the hair line on 67 of *D;* bring 74 on *C* under the line; then move the line to 8.2 of *C* and under it on *D* is 7.43, the unknown fourth term.

Square roots and squares on the slide rule are matters of a look only. The figure under the hair line on *D* is the square root of the figure under the hair line on *A.* Here the decimal point must be considered a little more. The figures on the left half of scale *A* represent all numbers from 1 to 9, 100 to 999, 10,000 to 99,999, i.e., all numbers having an uneven number of figures. The right half of the scale represents all numbers from 10 to 99, 1000 to 9999, etc.; all numbers of an even number of figures. If one forgets the rule, try it out with 4. Set the line on the left-hand "4" and "2" will be found under it. Set it on the right-hand "4" and 6.325 (as nearly as can be read) will be found under it.

$$\sqrt{4} = 2;\ \sqrt{400} = 20;\ \sqrt{40{,}000} = 200$$

$$\sqrt{40} = 6.324+;\ \sqrt{4000} = 63.24+ \text{ etc.}$$

Squares are the converse. Set the line on a figure on scale *D*, and the square will be found above on scale *A*.

Cubes are obtained by repeated multiplication on the lower scale. To cube 3.1, set the hair line on 3.1 of scale *D*, put the left-hand "1" of *C* opposite, and read 9.61 on *D* opposite 3.1 on *C*. Leave the hair line set on 9.61 and bring the right-hand "1" of *C* opposite it, then read 29.79 on *D*. A second method: Set the hair line on 3.1 of scale *D*, and read 9.61 on scale *A* above. Set the "1" of *B* opposite 9.61 of *A*, and read the cube on *A* opposite 3.1 on *B*.

Obtaining the cube root seems complicated, but is nowhere nearly so difficult as the same operation with paper and pencil. First reverse the slide, see Fig. 1. Then consider all numbers from 1 to 10 represented by the left-hand scale on *A*, 10 to 100 by the right-hand scale on *A*, and 100 to 1000 by an imaginary scale out to the right of the rule. To get the cube root of 9, set the hair line over "9" on the left-hand scale *A* and bring the right-hand inverted "1" of the inverted scale *B* under it, move the hair line along until it covers the same number on scales *B* and *D*. In this case it can be seen immediately that it is near 2, as 2 on *B* is opposite 2.118 on *D*, and 2.24 on *B* is opposite 2 on *D*. But 2.1 on *B* is opposite 2.064 on *D*, showing this is too much; 2.05 on *B* is opposite 2.093 on *D*, too little; 2.075 on *B* is opposite 2.082 on *D*, still too little; 2.080 seems to be about right. (The correct answer is 2.0802).

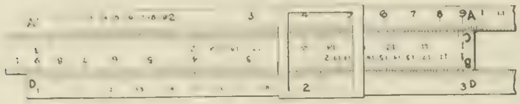


FIG 1

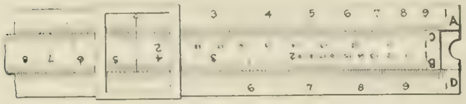


FIG 2

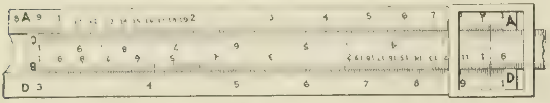


FIG. 3

POWER

To get the cube root of 90, set the hair line on the "9" (or "90") of the right-hand scale *A*, and bring the right-hand inverted "1" of scale *B* under it, as in Fig. 2; then, as before, move the hair line until the readings on *B* and *D* are the same. The 4 on *B* lies opposite 4.745 on *D*, and 5 on *B* lies opposite 4.245. The root lies between 4 and 5; 4.5 on *B* is opposite 4.47 on *D*; 4.475 on *B* is opposite 4.485 on *B*. This would indicate an answer of about 4.482. (The correct answer is 4.4814).

To obtain the cube root of 900, set the right-hand inverted "1" of scale *B* on an imaginary 900 out to the right of the scale, which means set the left-hand inverted "1" on the "9" on the left-hand A-scale, as in Fig. 3. The "9" on *B* is opposite "10" on *D*, and "10" on *B* opposite 9.48 on *D*; 9.5 on *B* is opposite 9.73 on *D*; 9.6 on *B* opposite 9.68 on *D*; 9.65 on *B* opposite 9.66 on *D*; so 9.655 is about the answer. (The true answer is 9.659, which indicates a high accuracy for this method of computation.

In this last case do not make the mistake of reading too far down the rule and attempting to find the answer again between 4 and 5. In this case it must be remembered that the "1" of the B-scale is the 10. In general this ambiguity must be avoided by remembering roughly that the cube root of 900 is near 9, not near 4. So, too, the cube root of 9000 would roughly be near 20, not near 10 or 50, where the *B* and *D* scales also give the same reading at about 1.480. That is, in cube and square root, as in finding the decimal point in multiplication, it is necessary to use a little discretion. So, too, the cube root of 90,000 is near 40 and not near 20 or 200 as might possibly be thought from a too quick look at the slide rule.

It was shown in the last lesson how, with the slide in its normal position, tables of multiples were given for each setting of the rule. With the slide inverted in the rule, as for cube root, but with the terminal "1s" brought opposite, a table of reciprocals is afforded, for each number on *A* will be above its reciprocal on *B*, or each number on *C* will be above its reciprocal on *D*. For instance, 4 on the left-hand scale *A* is over 25 on scale *B* ($\frac{1}{25} = 0.04$ or $\frac{1}{4} = 0.25$) and "5" on scale *C* is over "2" on scale *D* ($\frac{1}{2} = 0.5$ or $\frac{1}{5} = 0.2$).

A useful table available at one setting of the slide rule is that for areas of circles. If the right-hand "1" of *B* be set on $\frac{\pi}{4}$ (0.7854) of *A*, then if the hair line be set on any number on *C*, the area of the circle of that diameter can be read directly on *A*. (This should be tried.) For instance, opposite 2 on *C*, one finds 3.1416 on *A*, the area of a circle of a diameter of 2. On the other hand, with this setting, if the hair line is set on the area of a circle on *A*, the diameter is at once read on scale *C*.

Since a "table" is formed when the "1" of the slide is put opposite a number, any number of multiplications by a common factor can be made at one setting of the rule. Take the common factor on *D* or *A*, set "1" of *C* or *B* opposite it, and read the products successively without resetting the slide. Divisions usually take a fresh setting for each one, but if several different numbers are to be divided by the same number, e.g., 2.43, first get the reciprocal of the divisor $\frac{1}{2.43}$, which is found to be 0.412. Then multiplying the different numbers by this reciprocal is the same as dividing by the original divisor, and all of the operations can be done at one setting.

This by no means exhausts the capacity of a slide rule, as all sorts of trigonometrical problems can also be solved on it, but multiplication, division, raising to powers, extracting roots and solving proportions are the principal uses.

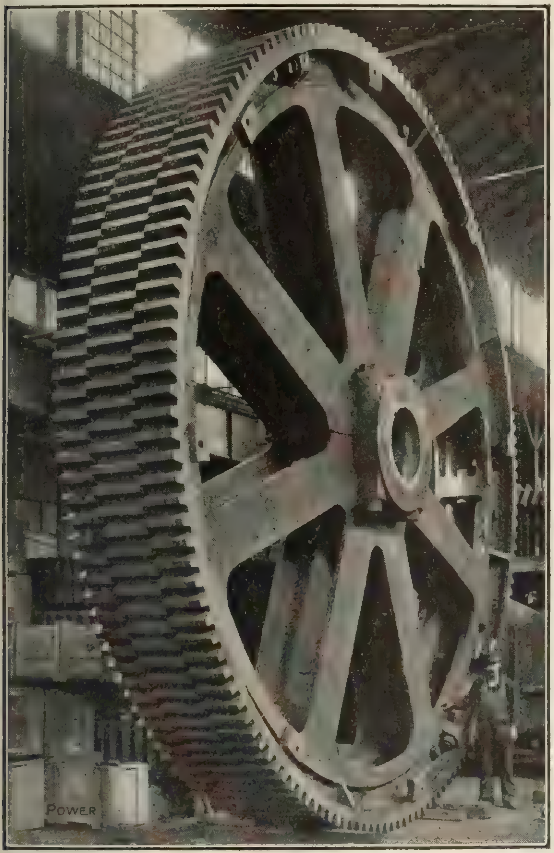
STUDY QUESTIONS

6. At one setting solve $\frac{33.4 \times 1.29}{0.492}$.
7. Solve the proportion $61 : 408 :: 32 : x$.
8. If the mean effective pressure remains the same, how much horsepower will an engine develop at 200 r.p.m. if it develops 45 hp. at 160 r.p.m.?
9. Find the square root of 42,200.
10. Find the cube root of 42,200.

Triple-Staggered-Tooth Steel Wheel

A steel gear, probably the largest of its kind ever manufactured, was shipped recently by the Mesta Machine Co., Pittsburgh, Penn., to the Inland Steel Co., Chicago, and will be used for driving a sheet mill. From this gear and pinion a single-stage speed reduction is obtained from the motor to the mill.

The gear is 22 ft. 8 in. in diameter, with a 38-in. face and 5½-in. circular pitch; the mating pinion is 2 ft. 11 in. in diameter; there are 154 teeth in the gear and 20 teeth in the pinion.



Triple Staggered-Tooth Steel Gear

The design varies from ordinary practice because the teeth are staggered in three sections. On account of the axial motion to which the drive is subjected it was necessary to use a spur gear. A herring-bone gear was not considered because of the unequal pressures that would be exerted on the side of the tooth face. It travels at a speed of 2000 ft. per min. and transmits 1600 hp. To meet the action of this high speed the gear was carefully cut, the teeth staggered, and the drive arranged to run in an oil bath.

The gear is built up of six parts. The center, including the arms, etc., carries the central rim segments of teeth; the two halves of the gear are bolted together, and the separate rims fastened by bolts running through the side of the central casting.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Lots of folks know Leonardo da Vinci only as the painter of Mona Lisa, who was kidnapped and recently returned to her guardians. Lenny was a big mechanical engineer as well as painter. If you live near Hoboken (and some people have to), go to Stevens Institute on the evening of Feb. 20 and hear John W. Lieb's lecture on Da Vinci, M. E.

*

"Peace, honor, freedom and prosperity" are wished us in President Wilson's recent message. Makes a fine message. Now, if he can make it stick, we'll be "thanking you in advance, and remain yours very truly." We can suggest lots of other nice things, but we can't seemingly get away with them.

*

A highly peeved party, hiding behind the signature "Subscriber," calls us dishonest because we allowed an advertiser to fill a vacancy before the ad. appeared. Come out in the open, Mister, and let's have your name (even if it be Mudd!) A common-sense man knows that when a concern wants an engineer it wants him quick. Suppose this afternoon an ad. was inserted for tomorrow morning's paper, and the advertiser met Mister Subscriber an hour after, and hired him. Would this Mister howl dishonesty and refuse the job? Not on your CO_2 recorder he wouldn't. Subscriber? We don't believe we have one who even thinks we are not square.

*

There's a powerful lot of money put into one of Uncle Sam's fighting plants. Take the "Texas," for instance. She represents $15,000,000! But we must have peace, even if we have to fight for it. And it's the engines that keep this mass moving—give it impetus! Makes you throw out your chest, eh?

*

We asked a friend of ours, a boiler inspector, to send us some dope regarding a recent boiler-rules meeting. Here's his answer: "We had the Board, something to eat, nothing to drink—and the usual speeches." The lucidity of this account ought to help the operating engineer mightily. That's the reason we print it.

*

When we read that a mite of a baby had been sent through the mails" by the parcels post, rightside up and unharmed, to (sex unknown) its destination, we thought our parcels post was some punkins! Now, we are doubtful, for "Indian Engineering" says "The Postmaster-General of Bengal left for Siliquri on Monday by the Darjeeling mail."

*

WHEREAS, AND BE IT RESOLVED—

BY BILLY SPILLS

You've met up with one of those "whereas" things that they hang a Congressional bill on? It starts off with about 23 hand-picked and wrapped whereas-es, gathers impetus on a 200 per cent. overload of legal garbage (or is it verbiage?), and discharges at high velocity into the be-it-resolved hotwell.

Then, being a layman, you say, "What ther ———" (fill in to suit). And your mind harks back to the time brother Willie got his panties on 'hindside before—you didn't know if he was going or coming.

Just you turn over to page 238 and under the caption "The Aftermath," you will find an apt illustration. What damming the Mississippi would do for the folks on its sandbagged banks, according to the tell of the power company, would make Henry Ford look like two bits. Then about the time the dam dammed its hardest the industrial folks woke up. They started to sic the Congressional canine to barking up the whereas tree, and now he has brought down a full-grown resolve that measures 14 in. from the tip of its "whereas" to the end of its "resolved, further."

It is astounding how many good working American words can be hidden away in an 18-karat cluster of whereas-es and a solitaire be-it-resolved. Now, Congressman Rainey seeks to undo those things which were overdone and do over those things which were underdone.

In the meantime, we will save up further comment for a Rainey day, hoping that the Congressional sun will soon after dispel the clouds that at present hang threat'ning o'er the Mississippi.

How to Calculate the Losses in Gas Engines

By George W. Munsch

SYNOPSIS—Simple calculations showing how to figure the heat balance of a gas engine with a degree of accuracy close enough for ordinary purposes.

⁂

Calculation of the heat losses in a gas engine is a matter of the simplest arithmetic and it is necessary only to understand a few principles regarding heat. In the following calculations no attempt is made to go deeply into the subject of heat or heat transfer; just enough is given to show how various heat losses are obtained.

The losses comprise the heat given up to the jacket water, that carried off in the exhaust gases, both as sensible heat and unburned gases, and radiation and conduction. When calculating the exhaust losses gases are dealt with and not water, which somewhat complicates the problem.

When obtaining the exhaust losses it is necessary to know the weight of a cubic foot of the gas, also its specific heat, which is the ratio of the heat required to raise that substance one degree to the quantity required to raise an equal weight of water one degree. The specific heat of air at constant pressure is 0.2375 and that of the exhaust gases may be assumed as 0.245. For accurate calculations, the exact specific heat of the mixture must be ascertained. The volume of mixture passed through the exhaust is found by multiplying the piston displacement by the number of explosions, and the temperature in the exhaust pipe is measured as near the engine cylinder as possible. The heat lost in the exhaust per hour is found by multiplying the weight of 1 cu.ft. of the mixture, by the cubic feet exhausted per hour, by the specific heat, and by the temperature change. This can be expressed in a formula as follows:

$$B.t.u.\ per\ hr. = WSQ\ (T - T')$$

where

W = Weight of 1 cu.ft. of mixture at exhaust in lb.;
S = Specific heat of the mixture;
Q = Cubic feet of mixture exhausted per hr.;
T = Temperature of the exhaust gases;
T' = Room temperature.

The radiation loss plus the loss due to incomplete combustion is found by subtracting the sum of the cooling-water loss, the exhaust loss and the heat turned into mechanical energy from the total heat supplied to the engine.

One B.t.u. is equivalent to 778 ft.-lb., and since 33,000 ft.-lb. per min. represents 1 hp.

$$B.t.u.\ per\ hr. = \frac{i.hp. \times 33{,}000 \times 60}{778} = 2545 \times i.hp.$$

Having determined the methods for finding the heat losses as well as the heat supplied to the engine, the next step is the heat or thermal efficiency. This is the ratio of the heat absorbed in work to the heat supplied to the engine by the fuel.

The heat losses are about as follows: Jacket loss, 30 to 50 per cent., with an average of 40 per cent.; exhaust loss, about 30 to 35 per cent., and radiation loss, about 5 per cent. The thermal efficiency varies from 15 to 35 per cent. with 20 to 25 per cent., a fair average.

The following problem covers a test of a four-stroke-cycle engine and in order to make the calculations complete the mechanical results will be figured as well as the heat losses:

PROBLEM

Engine data	
Diameter of cylinder, in	8.5
Area of piston $(8.5)^2 \times 0.7854$, sq.in	56.75
Length of stroke (L), in	18
Clearance, cu.ft	0.25
Flywheel circumference, ft	16
Test data:	
Rope brake on the flywheel to load the engine	
Net weight on brake, lb	93
Speed, r.p.m	175
Average explosions per min (E)	80
Mean effective pressure (P), lb	45
Gas used per explosion, cu.ft.	0.07
Weight of gas per cu.ft., lb.	0.084
Heat value of the gas per cu.ft., B.t.u	300
One pound of the air at room temperature (68 deg. F.) = 14.2 cu.ft	
Cooling water used, lb. per explosion	0.13
Cooling water temperature change, deg. F	65
Temperature of exhaust gases above room temperature, deg. F.	60

To be determined:

1. Indicated horsepower.
2. Brake horsepower.
3. Mechanical efficiency.
4. Cubic feet of gas per hour.
5. Cubic feet of air per hour.
6. Ratio of air to gas.
7. Heat supplied per hour.
8. Heat taken up by the cooling water per hour.
9. Heat in exhaust gases.
10. Heat turned into mechanical energy (i.hp.).
11. Heat turned into useful work (b.hp.).
12. Thermal efficiency of the engine.
13. Balance of the heat losses.

Solution:

1. $I.hp. = \frac{PEAL}{33{,}000} = \frac{45 \times 80 \times (8.5)^2 \times 0.7854 \times 1.5}{33{,}000} = 9.27.$

2. Brake horsepower equals net load on the brake times circumference of the flywheel × r.p.m. ÷ 33,000

$$B.hp. = \frac{93 \times 16 \times 175}{33{,}000} = 7.88$$

3. $\text{Mechanical efficiency} = \frac{\text{brake horsepower}}{\text{indicated horsepower}} = \frac{7.88}{9.27} = 85$ per cent.

4. $0.07 \times 80 \times 60 = 336$ cu.ft. of gas per hour.

5. $\text{Displacement of the piston} = \frac{(8.5)^2 \times 0.7854}{144} \times 1.5 = 0.593$ cu.ft.

$(0.593 - 0.07)\ 80 \times 60 = 2510$ *cu.ft. of air per hr.*

6. Ratio of air to gas = 2510 ÷ 336 = 7.46.

7. Heat supplied by the gas per hour = 336 cu.ft. × 300 B.t.u. = 100,800 B.t.u.

8. Heat taken up by cooling water:

Quantity of water used per hour = 0.13 × 80 × 60 = 624 lb.

Temperature change = 65 deg.

B.t.u. given up to cooling water per hour = 624 × 65 = 40,560 and

$$\frac{40,560}{100,800} = 40.24 \textit{ per cent.}$$

9. 2510 cu.ft. of air per hour ÷ 14.2 = 176.7 lb. of air per hour.

336 *cu.ft. of gas per hr.* × 0.084 = 28.22 *lb. of gas per hr.*
176.7 + 28.22 = 204.92 *lb. of mixture per hr.*
Specific heat of exhaust = 0.245.
Change in temperature of the gas = 600 deg. F.
204,92 × 600 × 0.245 = 30,123 *B.t.u.*
30,123 ÷ 100,800 = 29.88 *per cent.*

10. Heat turned into mechanical energy = 2545 × i.hp. = 2545 × 9.27 = 23,592 B.t.u.
23,592 ÷ 100,800 = 23.4 *per cent.* (*thermal efficiency*)

11. Heat turned into useful work = 2545 × b.hp. = 2545 × 7.88 = 20,054 B.t.u.

12. Net thermal efficiency of the engine = 20,054 ÷ 100,800 = 19.89 per cent.

13. Cooling water loss = 40,560 B.t.u.
Exhaust loss = 30,123 B.t.u.
Heat turned into mech. work = 23,592 B.t.u.
Total = 94,275 B.t.u.

Balance of heat losses = 100,800 — 94,275 = 6525 B.t.u.

6525 ÷ 100,800 = 6.47 *per cent.*

* * *

The Deterioration of Engines and Boilers

By Edward Ingham

The question of "wear and tear" of steam-plant apparatus is of importance to the steam-power user, especially where large plants are concerned. Certain parts of a steam engine, constantly rubbing against one another, cause wear. An engine piston wears the walls of the cylinder and the piston rings also gradually become reduced. The rotation of the crankshaft wears the bearings; other parts wear in like manner. The extent of wear taking place depends largely on the engineer in charge, the design of the engine, and the manner in which the engine was erected.

Excessive wear is sometimes caused by the settling of the foundations, throwing the engine out of line. This is sometimes caused by the mortar of the foundations becoming saturated with oil, which has a destructive effect; it will also affect concrete foundations. They should, therefore, be protected from oil by suitable drip oil pans.

If an engine is adjusted too tightly, increased friction and wear, hot bearings, etc., will result; if too slack, the engine may knock and stresses be set up with the risk of incurring a breakdown. The practice of cooling hot bearings by pouring cold water over them is risky and may cause a fracture.

Fatigue of Metal

In addition to the deteriorating influence of "wear and tear," there is the factor of fatigue, which plays a most important part in reducing the working life of a steam engine, and cannot well be avoided. By this is meant the weakening which certain metals suffer when exposed to a large number of repetitions of stress.

Both the piston rod and the connecting-rod of a steam engine are subjected to a tensile and a compressive load at each revolution, the effect of which is to lead to disintegration and weakening, particularly if the range of stress is high. Where only low factors of safety are adopted in the design, the probability of failure and breakdown from fatigue is much greater than where the margin of safety is large. It would be possible to almost entirely do away with fatigue, by making the parts of such strength that the working stresses would be very low, but this would necessitate massive and costly parts; hence in actual practice fatigue is always to be considered. To reduce the risk of engine breakdown resulting from weakened parts by fatigue, it is becoming the practice for some insurance companies and experts to advise owners to renew the more severely stressed working parts, after these have been in use a certain number of years, whether they show signs of weakness or not. Experience has shown that engines do break down from fatigue.

Two beam engines built from the same patterns, were supplied for driving a large textile mill. Both engines were put to work at the same time and under the same conditions. After working for nearly 20 years, the beam of one engine broke. Within a short time the beam of the other engine similarly failed. During the years these engines had been running each beam had made about 200,000,000 oscillations.

Boiler Deterioration

The principal cause of boiler deterioration is the wasting away of the plates, both internally and externally, until they become too weak to safely withstand the pressure to which they are exposed. Internal corrosion is caused by impurities in the feed water, galvanic action, etc. This defect can usually be prevented by adding suitable chemical reagents to neutralize the acid action of the water, or, in the case of galvanic action, by placing zinc blocks in the boiler.

External corrosion is caused by allowing the external plate surfaces to become damp, and can easily be prevented by preventing moisture coming in contact with the plates. Its existence is generally an indication of carelessness and ignorance on the part of those responsible for the maintenance and upkeep of the boiler. There are, however, other influences than corrosion which tend to reduce the working life of a boiler. If the feed water deposits much scale and dirt in the boiler, trouble from overheating, straining and leakage will be experienced, unless special care is given to cleaning and washing out the deposits.

The most that a boiler compound can do is to soften the scale so that it can be readily removed. Unless the water is treated before being fed into the boilers, frequent cleaning is quite as necessary, if not more so, when reagents are used as when not. If the plates be kept free of scale and deposits overheating will not occur. The presence of a very small quantity of grease in a boiler is likely to cause serious trouble; this is particularly true if the feed water contains deposits of lime and magnesia.

The life of a boiler is influenced by the person in charge. A fireman who allows the fire bars to become bare, so that a large volume of cold air rushes into the furnaces, or who raises steam rapidly and then opens the furnace doors to admit cold air to prevent the safety valves from blowing, is responsible for weakness and deterioration. Some firemen do not allow a reasonable time in which to raise steam and, when laying a boiler off for cleaning or inspecting, will blow off under pressure. It is not uncommon for the more ignorant firemen to actually play cold water over the hot plates immediately afterward. This is bound to cause excessive straining of the plates, and would account for seam troubles.

Even with good working conditions serious defects will appear, if the design and construction are not of the best, or if the boiler has been improperly set. Unless contraction and expansion strains are cared for, deterioration and disintegration will begin as soon as the boiler is put in service.

An experienced inspector can readily detect signs of incipient deterioration before any real mischief is done long before an ordinary engineer not skilled in this particular duty would detect them.

* *

The Cause and the Remedy for Clinkers

By F. Webster

SYNOPSIS—The clinker problem is a slag problem. When analysis of a coal shows presence of impurities in proportions favorable to formation of slag, the proportions may be changed and formation of slag prevented by adding some of the same substances. The usual chemical combinations in slag making are explained with examples. The objections to the presence of sulphur is overestimated; it is sometimes beneficial.

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Most firemen have noted the formation of clinkers, and have exercised much mental and physical effort to prevent and to get rid of them. That the burning of some kinds of coal never forms clinkers is well known, and it is also known that with other kinds of coal a large proportion of the incandescent bed of fuel seems to fuse down to a liquid which is often so thin as to trickle into the ashpit. In a locomotive firebox the liquid slag is often so limpid that the strong lift of the draft will raise it from the grates and splash it over the flue sheet and other heating surfaces, where it hardens and becomes a foe to boiler efficiency.

The questions which naturally present themselves are: What is the clinker which sometimes collects in large masses over the grates? Why is it formed by some coals and not by others? What are the remedies, and, finally, can we tell beforehand whether or not a given grade or shipment of coal will or will not clinker? For many purposes it is highly important that the coal burned on a boiler grate will not clinker, and both annoyance and expense may be obviated if reliable tests can be applied before the coal is purchased.

The clinker problem is a slag problem, and to intelligently cope with the question of clinker in a boiler furnace one should understand the principles which underlie the formation of slag.

A glass bottle is an example of a slag which has been made and formed to order. White sand and "salt cake" in the correct proportions are heated together until they unite chemically and form a fluid which we call glass. This is colored to suit the requirements of the trade by adding some suitable material to the mixture before it is heated. Thus, gold makes the ruby-red glass; arsenic, white; cobalt, blue; iron, green and black; magnesium, a violet; uranium, a yellow, etc. In glass making a perfect slag is formed because the proportions of the ingredients are correct and exact treatment is given in the process.

In the boiler furnace, however, the coal furnishes the entire stock as the heat necessary for fusion and slag comes from such impurities in coal as iron, sand, clay, lime, sulphur, magnesia, etc. It is the sand when heated with the lime, iron, clay, etc., that forms the fluid mass like the glass mentioned above, but one that is irregular in composition and varied in color according to the impurities present in the coal. This slag flows over the ash and other ingredients that are not melted, and when cooled, cements the particles together and forms the hard ugly mass which we call clinker. The cementing of the ash by the slag may be likened to the making of a popcorn ball in which grains of corn are stuck together by a coating of molasses. The iron gives the clinker its reddish or brownish color, which is modified by the color of the enveloped particles and other conditions, so that the resulting color may be anything from a white to a black.

Iron and sulphur when present as impurities usually form with coal a compound called pyrites, sometimes called "fool's gold," owing to its yelow metallic appearance. The sulphur may also be in combination with the lime, forming a compound known as gypsum. Speaking chemically, the sand is an oxide of silicon; the clay is an oxide of aluminum; likewise the magnesia and the lime are oxides of the metals magnesium and calcium respectively, meaning that they have united with oxygen to form the rust or ash of those metals.

In order to make a slag, an acid substance must be heated with a basic substance. The action will be to destroy the chemical affinity which each substance has in holding its elements together so that the two substances will unite with each other and form an entirely new compound. The acid substance is the sand, while the basic substances are the clay, lime, magnesia and the oxidized iron. As sulphur is uncertain it will not be considered for the present. The sand, lime, clay, etc., when heated alone will withstand very high temperatures; in fact, much higher than they are ever subjected to in boiler furnaces. But when mixed together and heated, they will melt easily, and in some cases make a thin and very fluid slag, especially where the mixture is proportioned so as to produce a new chemical compound. But it is important to observe that when either the sand or the base is greatly in excess, then a much higher temperature is required to do the melting; also that sand when mixed with two or more bases will sometimes melt at a lower temperature than where a single base is present. These are very important phenomena in formation of slag because they give us a means of preventing the formation of clinkers in the boiler furnace. Thus, by spreading some crushed limestone or oyster shells over the fire to increase the base, or if the proportion of sand is abnormally high, the fusing point will be higher than the temperature of the furnace and less clinker will form.

Slag formation is best understood when we have the viewpoint of the chemist. This is easily had even by the ordinary reader who does not understand chemistry. The chemist does not recognize any chance work, for he considers the elements as acting upon each other in perfect harmony, resulting in unity and completeness of combination and that nothing is lost in nature, but that changes take place and new compounds are formed, always in definite proportions of the elements, and the sum of the weights of the products is exactly equal to the weight the substances had before the changes took place. Hence in formation of slag nothing is created and nothing originally present can be annihilated.

In chemistry a term called the atomic weight is commonly used. This term expresses the relative weights of the elements of the various kinds in the proportions that they unite with each other to form compounds. An element is a substance, such as gold, sulphur, oxygen, hydrogen, etc., that has never been separated into other substances. As examples of atomic weights, that of iron is 56 and that of oxygen is 16. The combination of iron and oxygen, known as ferrous oxide, which we will consider later when discussing its effect in making clinkers, has a molecular weight of 56 + 16 = 72; that is, the molecular weight refers to the weight of the compound. Finally, the chemist uses a kind of shorthand in writing the names of elements and their compounds so as to show all the facts in one short expression; thus, Fe stands for iron, O for oxygen, and Si for silicon. Likewise, FeO stands for ferrous oxide, showing that it is made up of equal parts of iron and oxygen; FeS_2 stands for pyrites mentioned above, which is a compound having one part of iron to two parts of sulphur; SiO_2 is silicon dioxide, or sand, which is made up of one part of silicon and two parts of oxygen.

TABLE I.

Elements			Compounds		
Name	Symbol	Atomic Weight	Name	Symbol	Molecular Weight
Aluminum	Al	27	Lime	CaO	56
Calcium	Ca	40	Silica (sand)	SiO_2	60
Carbon	C	12	Aluminum (clay)	Al_2O_3	102
Hydrogen	H	1	Ferrous sulphide	FeS	88
Iron	Fe	56	Iron disulphide (Pyrites)	FeS_2	120
Magnesium	Mg	24	Calcium sulphate (Gypsum)	$CaSO_4$	136
Oxygen	O	16	Magnesia	MgO	40
Silicon	Si	28	Sulphur dioxide	SO_2	64
Sodium	Na	23	Water	H_2O	18
Sulphur	S	32	Calcium Monosilicate	Ca_2O_4Si	172
			Ferrous Monosilicate	Fe_2O_4Si	204
			Magnesium Monosilicate	Mn_2O_4Si	140
			Aluminum Monosilicate	$Al_4O_{12}Si_3$	384
			Ferrous oxide	FeO	72

Table I* gives names, chemical symbols, and the relative atomic weights and molecular weights of substances usually assigned to elements and combinations commonly met with in fuel, ash and clinker in boiler practice.

By monosilicate as noted in the last four items in the table is meant a compound made by the silica, SiO_2, uniting with any base in such a proportion that the amount of oxygen in the base is the same as that in the sand. Hence, it will be seen that two of lime, CaO, or of ferrous oxide, FeO, etc., must be used with the one part of sand, SiO_2, in order to get O_2 in the base. With the clay, Al_2O_3, two parts must be used for every three of sand, SiO_2, so as to get the oxygen in the silicon to balance that in the clay.

The method of finding out by means of slag calculations whether or not a given coal will clinker, and if so why it clinkers and how the clinkering may be prevented, will be understood from the solutions of a few examples.

The slag test is based on the analysis of the coal ash. Thus, the analysis of a certain coal ash is: Silica, 33.5 per cent.; alumina, 24.2 per cent.; lime, 19.5 per cent.; ferrous oxide, 14.3 per cent.; magnesia, 5.7 per cent.; and sulphur, 2.5 per cent. As these various bases will unite with the silicon, the first thing to do is to find out whether or not there is enough silica to fuse all of them, and to see which predominates—the bases or the silica. To get these proportions we must use the molecular weights given in the table, thus:

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*The atomic weights quoted by the author are those commonly used for practical computations, though not strictly in accordance with the most recent values employed in chemistry in which the weights are referred to O = 16 and H = 1.008. The figures recommended by the Eighth Congress of Applied Chemistry to be used in all commercial work until 1915 are given below in the table of weights, quoted from "The Engineering and Mining Journal" of Jan. 18, 1913.—Editor.

INTERNATIONAL ATOMIC WEIGHTS

Element	Symbol	Weight	Element	Symbol	Weight
Aluminum	Al	27.1	Molybdenum	Mo	96.0
Antimony	Sb	120.2	Neodymium	Nd	144.3
Argon	A	39.88	Neon	Ne	20.2
Arsenic	As	74.96	Nickel	Ni	58.68
Barium	Ba	137.37	Niton	Nt	222.4
Bismuth	Bi	208.0	Nitrogen	N	14.01
Boron	B	11.0	Osmium	Os	190.9
Bromine	Br	79.92	Oxygen	O	16.00
Cadmium	Cd	112.40	Palladium	Pd	106.7
Caesium	Cs	132.81	Phosphorus	P	31.04
Calcium	Ca	40.07	Platinum	Pt	195.2
Carbon	C	12.00	Potassium	K	39.10
Cerium	Ce	140.25	Praseodymium	Pr	140.6
Chlorine	Cl	35.46	Radium	Ra	226.4
Chromium	Cr	52.0	Rhodium	Rh	102.9
Cobalt	Co	58.97	Rubidium	Rb	85.45
Columbium	Cb	93.5	Ruthenium	Ru	101.7
Copper	Cu	63.57	Samarium	Sa	150.4
Dysprosium	Dy	162.5	Scandium	Sc	44.1
Erbium	Er	167.7	Selenium	Se	79.2
Europium	Eu	152.0	Silicon	Si	28.3
Fluorine	F	19.0	Silver	Ag	107.88
Gadolinium	Gd	157.3	Sodium	Na	23.00
Gallium	Ga	69.9	Strontium	Sr	87.63
Germanium	Ge	72.5	Sulphur	S	32.07
Glucinum	Gl	9.1	Tantalum	Ta	181.5
Gold	Au	197.2	Tellurium	Te	127.5
Helium	He	3.99	Terbium	Tb	159.2
Holmium	Ho	163.5	Thallium	Tl	204.0
Hydrogen	H	1.008	Thorium	Th	232.4
Indium	In	114.8	Thulium	Tm	168.5
Iodine	I	126.92	Tin	Sn	119.0
Iridium	Ir	193.1	Titanium	Ti	48.1
Iron	Fe	55.84	Tungsten	W	184.0
Krypton	Kr	82.92	Uranium	U	238.5
Lanthanum	La	139.0	Vanadium	V	51.0
Lead	Pb	207.10	Xenon	Xe	130.2
Lithium	Li	6.94	Ytterbium	Yb	172.0
Lutecium	Lu	174.0	Yttrium	Yt	89.0
Magnesium	Mg	24.32	Zinc	Zn	65.37
Manganese	Mn	54.93	Zirconium	Zr	90.6
Mercury	Hg	200.6			

The silica unites with the lime to form a calcium monosilicate, or

$$\begin{array}{ccccc} \text{Sand} & & \text{Lime} & & \text{Monosilicate} \\ SiO_2 & + & 2\,CaO & = & Ca_2O_4Si \\ 60 & + & 112 & = & 172 \end{array}$$

that is,

$\frac{60}{172}$ = about 0.35 of the compound would consist of silica. Likewise, for the clay the silica required is found from the equations:

$$\begin{array}{ccccc} \text{Sand} & & \text{Clay} & & \text{Monosilicate} \\ 3SiO_2 & + & 2Al_2O_3 & = & Al_4O_{12}Si_3 \\ 180 & + & 204 & = & 384 \end{array}$$

showing that $\frac{180}{384}$ = about 0.47 of the compound would consist of sand; and for the magnesia

$$\begin{array}{ccccc} \text{Sand} & & \text{Magnesia} & & \text{Monosilicate} \\ SiO_2 & + & 2MgO & = & Mg_2O_4Si \\ 60 & + & 80 & = & 140. \end{array}$$

or

$$\frac{60}{140} = \text{about } 0.43$$

and for the iron

$$\begin{array}{ccccc} \text{Sand} & & \text{Ferrous oxide} & & \text{Monosilicate} \\ SiO_2 & + & 2\,FeO & = & Fe_2O_4Si \\ 60 & + & 144 & = & 204. \end{array}$$

or

$$\frac{60}{204} = \text{about } 0.30 \text{ of the compound.}$$

The amount of silica taken care of by all the bases found in the ash will be the sum of the products obtained from multiplying the percentages of the bases in the ash by the factors worked out above, i.e.:

	Per Cent.
By the CaO (lime)	19.5 × 0.35 = 6.825 per cent.
By the Al_2O_3 (alumina)	24.2 × 0.47 = 11.374 per cent.
By the MgO (magnesia)	5.7 × 0.43 = 2.451 per cent.
By the FeO (ferrous oxide)	14.3 × 0.30 = 4.290 per cent.
Silica taken care of by bases in the ash	= 24.940 per cent. of the ash.

Referring to the analysis of the ash, 33.5 per cent. of silica was present, which is enough to take care of the 24.94 per cent. required by the bases and with possibly enough left over to affect the thinness of the slag and prevent the formation of clinker.

Effect of Sulphur

Some engineers charge the formation of clinkers to the sulphur in the coal. This is wrong, for, as a matter of fact, the sulphur will prevent clinker. The reason for this is that iron has a greater affinity for sulphur than it has for silicon, at least it has in a boiler furnace where the temperature is not high enough for their union as is the case in a blast furnace. As previously stated, the sulphur exists in the coal as pyrites, FeS_2, and when the compound is heated to about 1000 deg. F. or more, one part of the sulphur is driven off. This unites with two parts of oxygen from the air and forms sulphur dioxide, SO_2, which is the same as the gas formed from burning a sulphur match. The remaining compound, FeS, is very stable and will not be broken up so as to leave the iron free to unite with the silicon of the sand. As iron oxide and silica form an easily fused and very limpid slag, it follows that the action of the sulphur in keeping the iron from the silicon prevents slag formation, at least insofar as the iron is concerned. An example of a coal ash containing considerable sulphur will show this. Take the analysis of an ash as follows:

Alumina, 14.36 per cent.; ferrous oxide, 14.12 per cent.; magnesia, 19.75 per cent.; silica, 30.16 per cent.; sulphur, 6.4 per cent.

From the values in the table quoted it is to be seen that the amount of iron in the ferrous oxide, FeO is $\frac{56 \times 100}{56 + 16} = 78$ per cent. The iron in the ash = 14.12 per cent. × 0.78 = about 11 per cent. in ferrous sulphide, FeS, it takes 56 parts of iron for every 32 parts of sulphur; hence, for one part of sulphur it takes 56 ÷ 32 parts of iron, and for 6.4 per cent. sulphur, as given in the ash, it will require (56 ÷ 32) × 6.4 per cent. = 11.2 parts of iron to take care of the sulphur. Referring to the computation given immediately above, it will be seen that the ash has 11 per cent. iron, which happens to be practically the same as that required by the sulphur. Therefore, there will be no iron left to slag with the sand. In other words, the sulphur has killed the best base in the ash for making clinkers. In case the silica is low, there will be little chance to make clinkers with this coal.

The Size Limit of Large Steam Turbines*

SYNOPSIS—The size of the unit is limited by the restrictions of transportation, and by the high cost of exceptionally large forgings and castings. The capacity depends upon the amount of steam which can be passed through the low-pressure blading of this limited size of disk or drum without sacrificing too much to residual energy to induce a rapid outflow.

In the earlier days of power-plant development, when breakdowns were prevalent, security was sought in a minute subdivision of the plant into relatively small units.

In general, the cost of providing for a given aggregate output is the greater the greater the number of units. For this there are several reasons; one important factor is that what may be called the "noneffective" cost of a steam turbine is proportionately much greater the smaller the unit. The cost in question comprises that of the governor and its gear, the valve-gear, the oil pump, the tachometer, and similar accessories. In the case of a 500-kw. unit, the cost amounts to about 45 per cent. of the total construction, falling, in a 1000-kw. unit, to 40 per cent., and in a 10,000-kw. unit to 30 per cent. Hence, even if the "effective fraction" of a complete turbine costs the same per kilowatt for a small unit as for a large one, the total cost would be more with the smaller sizes. Actually, this argument understates the case for the larger unit. In fact, the same casing is sometimes used for a 5000-kw. machine as for a 7000-kw. unit and at the same speed, so that the turbine costs proper are almost identical. Some saving results from a smaller condenser being required with the smaller output, but the floor space occupied will be larger the greater the number of units, and the efficiency of small prime movers is markedly less than that of large ones.

To this rule the internal-combustion engine forms an exception, the efficiency attained with a 60-hp. engine being about as high as with an engine ten or twenty times its size.

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*Abstract from "Engineering," London.

With some forms of prime movers other than the gas engine, the limit of size is less definitely circumscribed by purely mechanical considerations. Theory shows that a limit must exist, since all prime movers are ultimately subject to the law that, while the output increases as the square of the dimensions, the weights involved increase as the cube. For the present, anyhow, this consideration hardly affects the question as to what is the limiting size of a steam-turbine unit. The latter is determined by difficulties of transport and by the high cost of exceptionally eavy castings and forgings. If a power station is intended to furnish a three-phase supply at 25 cycles, the turbo-alternator must run at either 750 or 1500 r.p.m. If the former be chosen, the limit of size is definitely fixed y the question of transportation, the loading gage on British railways restricting the diameter of a drum rotor ver the blade to about 8 ft. 6 in. and the diameter of a isk to about 13 ft.

An interesting point which then arises is the maximum utput possible with rotors of the dimension stated, and epends essentially on two factors, the centrifugal stresses nd the vacuum obtainable. Condensing plants have been o much improved that with a barometer of 30 in. a vacuum of 29 in. should be realized during most of the year. As delivered from an efficient turbine, the volume of 1 lb. f steam at a 29-in. vacuum is 600 cu.ft., making an average allowance for the wetness of the exhaust steam. If his steam is allowed to have an axial velocity at discharge f 440 ft. per sec. and the blade length is limited to one-ifth the mean diameter of the blading, the kilowatt output of the turbine cannot exceed the square of the mean iameter in inches of the last row of blades, assuming the ow steam consumption of 11.5 lb. per kw.-hr. If it is ssumed that the last row of blades is carried on a disk 3 ft. in diameter over blade-tips, the maximum output ossible from a single-flow turbine operating with a 29-in. acuum and a "carry-over"* loss of about 4 B.t.u. would e about

$$130^2 = 16{,}900\ kw.$$

By admitting a carry-over loss of 9 B.t.u., this output ould be increased to about 25,000 kw. If the vacuum ere limited to 28 in., the possible output would be 33,-00 kw. with a carry-over loss of 4 B.t.u., and about 28,-00 kw. with a carry-over loss of about nine heat units.

Allowing for a reheat factor of, say, 1.05, the heat vailable with steam at 200 lb. absolute and 200 deg. F. uperheat, expanded down to 28 in. vacuum, is about 391 .t.u. per pound; while if the expansion be carried to 29 vacuum the corresponding figure is about 428 B.t.u. n exhaust loss of 4 B.t.u. is about 1 per cent. of the total ergy available, and one of 9 B.t.u. per pound about 2¼ r cent. To get 33,000 kw. out of a single-flow turbine ith a 29-in. vacuum, would necessitate an axial velocity discharge of about 880 ft. per sec., and the carry-over ss would amount to nearly 16 B.t.u. An increase of cuum from 28 to 29 in. would still result in a saving of eam since the heat available on expansion to the lower mit is about 37 B.t.u. more. An attempt to get 48,000 . out of the turbine with a 29-in. vacuum, however, would be futile, as the carry-over losses would be so greatly increased as to cancel almost all of the difference in the heat available with a 28-in. and a 29-in. vacuum.

There would, of course, be no difficulty in running a wheel of the size proposed at 750 r.p.m. In fact, experience with a DeLaval turbine shows that the speed limit might be raised to 1100 r.p.m. without exceeding limits of safe stress in practice. A 300-hp. DeLaval wheel has a mean diameter of 30 in., the blade being about 1.25 in. in usable length, and the speed 10,600 r.p.m. If every part of the wheel were increased in direct proportion to a mean diameter of 130 in., the stresses would be as before, provided the revolutions were reduced in the ratio of 30 to 130 (to about 2440 r.p.m.). The blade length would then be 5.5 in. If the length of these blades were next increased to 26 in., their weight and the stresses in them would increase about 4.75 times. To reduce the stress to its original limit the speed must be divided by $\sqrt{4.75}$, becoming 1125 r.p.m. If the ratio of blade speed to steam speed were the same with a 26-in. blade as with the 5.5-in. blade, the bending stresses produced by the steam which drives them would be the same as before and the margin of security as great as in the original DeLaval wheel. This increase of blade length would also involve a diminution in the size of the wheel disk, so that the total stresses in the latter would be less than they were in the original wheel. By constructing the low-pressure portion of a turbine on the double-flow system the limiting outputs just stated may be doubled and hence large outputs are mechanically feasible in single units.

For the present, the practical limit for a turbine running at 750 r.p.m. is probably about 25,000 kw., and if of the drum type, questions of rail transport make it necessary to construct a motor for such an output on the double-flow system. The castings present less difficulty, as they can be built up in sections. The total weight of such a machine would be between 250 and 300 tons, that of the heaviest part to be lifted being between 30 and 40 tons. The sizes of the forgings required would be up to the limit of what can now be obtained, and the cost per ton of the large forgings and castings is considerably more than those of more moderate size. It is open to doubt whether units of this size are, save in exceptional cases, more advisable than those of about one-half to two-thirds the capacity in question; running at the alternative speed of 1500 r.p.m., the last row of blades might then have a mean diameter of 85 in. or a tip diameter of 8 ft. 6 in. and the output without extravagant losses to the exhaust might run up to fully 14,000 kw. In the double-flow type the highest economy could be attained with quite moderate stresses. The limit is, of course, the same for impulse as for reaction turbines. The output per ton is much more at 1500 r.p.m. than at 750, which is easily understood when it is remembered that the efficiency of a steam turbine depends largely on the "velocity ratio" or the ratio of blade to steam speed, which again with given steam conditions, depends on the "coefficient" or the revolutions^2 × mean diameter^2 × number rows of blades. For a stated number of revolutions, this coefficient is obviously proportional approximately to the volume of the turbine casing. It is thus seen that the volume of the turbine casing and the weight is only about one-quarter for 1500 r.p.m. of that required for 750 r.p.m. The smaller weights to be handled at the higher speed means, moreover, a much lighter construction of the engine house, smaller cranes and less massive foundations.

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*The carry-over loss is the loss in energy, expressed in at units, represented by the velocity and weight of steam ssing out of the last row of blades at the vacuum carried.

Apparently, there would be no difficulty in constructing an alternator of this output to run at the speed named. Last year, the Westinghouse Co. built alternators to run at this speed with an output of 20,000 kw. Since the output of an alternator varies nearly as the inverse square of the revolutions, or by the same law as that of the turbine, it should be easily practicable to run a unit developing 12,000 to 14,000 kw. at 1500 r.p.m.

In view of the ease of carriage, the light weights to be handled and the facility with which the turbine could be dismantled when required, it would seem that the smaller high-speed plant is really much to be preferred to the larger, and since the weight per kilowatt is less, the cost should also be lower, particularly in view of the high price of large castings and heavy forgings, to which attention has already been called. Moreover, with the large structure, distortions due to its own weight and to temperature variation, are more pronounced, making it necessary to adopt clearances proportionately larger in the larger units, so that the smaller machines might prove the more economical under test, though data on this point are still lacking.

Powdered Coal under Boilers*

By William A. Evans

Early experiments with powdered coal amounted to a general education and the discovery of the elementary principles upon which it operates. Failures were then primarily due to defects in pulverizing apparatus and that for feeding the powdered coal to the furnace. The principles of operation have become well established and the apparatus well standardized. The elements of good powdered-fuel combustion consist of finely ground coal, 90 per cent. through standard 100-mesh screen, thorough mixture of coal and air before entering the furnace, and good control of both coal and air. With these elements worked out properly, powdered fuel has shown marked economies on many furnaces and the results obtained are worth striving for in the case of boilers.

To the writer's knowledge, but two types of boiler have shown any success. Several attractive results have been obtained on horizontal return-tubular boilers, a battery of six having been operated for eight years at one plant and requiring but one man to run the entire plant. Of the water-tube type of boiler, none of the standard makes has shown any permanent results, although there is a boiler designed specially for powdered coal that, according to reports, is giving satisfactory commercial results. The return-tubular and this special boiler have combustion space for the amount of fuel burned much in excess of what is provided in most water-tube boilers. This large space seems to be the one essential.

The points of furnace design which are likely to bring about the successful use of this fuel under boilers are: Large combustion space, firebrick lined with no exposed boiler surface; means for disposing of ash; design of furnace, water cooled, that will insure a reasonable length of life to the firebrick setting, and provision for firing from a cold boiler without the use of auxiliary power to run the pulverizer and air supply.

In most experiments with boilers using powdered coal these four essential features of furnace design have been disregarded. Powdered coal requires a high temperature for ignition and for maintained combustion; at all parts of the furnace it should be at least 1800 deg. F. As these temperatures cannot be maintained and the combustion completed in contact with boiler-tube surfaces, a large space not in contact with the tubes has to be provided.

For the complete burning of powdered coal a space of one cubic foot for each boiler horsepower developed should be provided, because of the difficulty with which high-volatile coal burns on grates. Volatile gases escape from the grates, and unless there is a hot arch above and plenty of space, the gases escape to the tubes, where the flame is stifled with resultant smoke. The volatile matter is the most difficult part of the coal to burn with grate fires, but it becomes the more easily burned in the case of powdered-fuel combustion. This is because combustion of the coke occurs while suspended and traveling. In a hot furnace the volatile matter burns promptly while the coke burns as it travels forward, and the time required for combustion depends upon the size of the particle. The length of travel of the flame before it reaches the water tubes of the boiler should be such as to insure complete combustion, both volatile and fixed carbon, before it reaches the boiler surface. Large space then (one cubic foot for each boiler horsepower (maximum) is one of the first requirements of a boiler furnace using this coal. This space can be made doubly effective by causing the flame to make a double travel; that is, forward and backward, or up and down within the space, depending upon the design and local conditions.

Probably the most troublesome feature of powdered-fuel combustion under boilers has been the handling of the ash. When combustion is perfect, with the boiler operating at capacities required in present-day practice, heat is developed much above the fusing point of the ash or the brick, and both form a heavy slag hard to remove. In metallurgical furnaces this feature is taken care of in the slagging of other impurities, but fused ash in the boiler furnace is not so easily cared for. As it moves very sluggishly at a temperature of 2500 deg. and will become solid at 1200 deg., it is, therefore, difficult to remove, for as soon as any door is open for scraping out, it clings to the brickwork with a tenacity difficult to realize except after experience. It may be possible that a flux can be used to make this ash more fluid at low temperatures with small boiler capacities and exceptionally good coal, but the writer questions its practicability on large boiler capacities and on all grades of coal. He further believes that the ultimate solution of the use of powdered coal in boiler furnaces will include a positive means for continuously removing the ash.

In metallurgical work it is customary to frequently rebuild the furnaces, say, every eight to 12 weeks. In using powdered coal in these furnaces the life of the brickwork is somewhat reduced, usually requiring rebuilding every six weeks. Frequent rebuilding of boiler furnaces is highly objectionable, and the high temperatures of powdered coal will certainly destroy the best setting unless some new provision is made. It has been suggested that temperatures in the furnace be reduced by introducing excess air, but this is not practicable, as it would reduce the efficiency of the boiler. On the Bettington boiler as specially designed for powdered coal, the brickwork is maintained by the use of water-cooling tubes, the bricks being specially made to fit around the tubes. It would seem essential that furnaces be built with all the walls cooled by water tubes, the water in which is in circulation with that in the boiler.

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*"Power," Jan. 13, p. 69.

The matter of starting up from a cold boiler without auxiliary apparatus is, of course, possible of several solutions, and does not affect the primary success of the boiler in the burning of powdered coal. Fuel oil or gas might be used for getting up steam, or a grate could be incorporated in the design to permit of hand firing.

The features suggested necessarily require an elaborate change in boiler setting. The writer knows of but one case where any such elaborate change was made and that did show very intense heat with good combustion, but no provision was made for maintaining the brickwork, so it failed. The reason for the present-day lack of success with powdered coal under boilers is that each attempt has been made without any definite knowledge of what had previously been done or of the failures of others. Many attempts have been made by innocent purchasers of apparatus sold by ambitious promoters. In these cases the promoter knew nothing but the fact that powdered coal was giving success in some industries and that it ought to work to considerable advantage under boilers. Even if he knew that the redesigning of the setting was necessary or desirable, he would promote the sale by suggesting some slight change in the existing setting, hoping that enough would be developed to encourage the purchaser to continue to the ultimate success of the installation and education of himself.

It is fair to expect that, if a combination of the best elements of coal grinding, coal and air control, large combustion space, means for ash removal and brick maintenance be made in applying powdered coal to a boiler, there will be some success, and the economies already proved will be on the road to a commercial reality.

There is a good field for the use of powdered coal and we may expect to see it further developed.

School Engineers Banquet

The third annual banquet of the Engineers of Public Schools of Greater New York, was held in the Broadway Central Hotel, on Saturday evening, Feb. 7.

Hon. M. S. Stern, commissioner of education, commended the work of the engineers and stated that he was especially pleased to report that in over six years only four men in nearly 600 were found guilty of negligence of duty. F. G. McCann, engineer for the commission, told of the need of certain classes of equipment and expressed regret that those needs were not filled more rapidly.

Charles H. Bromley, associate editor of "Power," outlined recent progress in the power-plant field and urged the members to keep pace with it. They are primarily engineers, their janitor duties being incidental. Suggestions were offered to enable the men to perform their part in the greatest of school systems, a system which has about 570 schools, 20,000 teachers, 700,000 pupils and over 500 janitor-engineers.

THE ENGINEERS OF PUBLIC SCHOOLS OF GREATER NEW YORK

Samuel Donnelly, ex-commissioner of education and long connected with the school system, contrasted the crude work of years ago with the efficient methods now practiced.

John E. O'Brien, counsellor for the engineers, in speaking on the workingman's compensation act, said that he believed it applied to the janitor-engineers. Coroner Timothy J. Healy and national president of the Eccentric Association of Firemen commended the members on their splendid organization. Other guests were Commissioner of Education Lavelle and J. B. Hamlin, editor of "School." An enjoyable entertainment was given by Billy Murray and the Dixie Quartet through the courtesy of Jenkins Bros.

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Fatal Marine Explosion

The steamship "San Gregorio," largest oil-tank vessel afloat, came into Quarantine, N. Y., on Feb. 5, with her flag at half mast and reported one dead in the ship's company, another dying and two seriously injured. On the evening of Feb. 2 a steam chest had burst, causing the death of William Kemp, an assistant engineer, and scalding nearly all the men in the engine room. Kemp was literally boiled to death, according to Capt. J. E. Grey, of the "San Gregorio."

The "San Gregorio," which sailed from Rotterdam, Jan. 19, had experienced heavy weather and was still in a heavy gale on the night when the accident happened. With the bursting of the steam chest, Kemp, so the men who were with him said, ran back to shut off the steam. He was met with the full force and felled in his tracks. The other men made a dash for the upper deck. In running over the gratings and up the iron stairways some of them fell and were pulled along by their companions. Capt. Grey said that there were many heroic acts.

Kemp's body was found after the steam had been shut off. His face was unrecognizable. They buried him at sea at sunrise the following morning. The three badly scalded men were placed in an improvised hospital and were there when the "San Gregorio" came in.

The "San Gregorio" is owned by the Eagle Oil Transport Co., of London, and came in ballast. She has a capacity of 100,000 barrels.

Rate Regulation News

One of the most sweeping reductions in power rates which has been effected since the Railroad Commission was organized in California has just been made and will go into effect March 1, 1914.

The Southern California Edison Co. has just filed with the Railroad Commission a revised schedule reducing the rates for electrical power covering practically the entire southern part of the state. This reduction is the result of several weeks of negotiations between representatives of the Edison company and the Railroad Commission. About a year ago, after informal negotiations between them the company put into effect throughout the southern part of the state a maximum lighting rate of 8c. per kw.-hr. The rate, theretofore, had averaged between 9 and 10c. per kw.-hr. The effect of the reduction to 8c. amounted to a saving of approximately $240,000 per year.

Further negotiations have secured a second reduction in power rates. The new schedule just filed provides for a maximum lighting rate of 7c. per kw.-hr. and make an immediate saving to the patrons of the Edison company of at least $120,000 per year. It is estimated that the ultimate effect will be a general saving to patrons of electric energy of at least $200,000 per year.

Investigation before the Public Utilities Commission of Idaho of the rates charged for electric energy served by the Great Shoshone & Twin Falls Water Power Co., the Beaver River Power Co., and the Idaho Light & Power Co., has been ordered, commencing Jan. 26. This is the result of a complaint filed against the former company by the trustees of the city of Wendell, which charged discrimination in rates.

The Beaver River and the Idaho Light & Power Companies are given the choice of participating in the investigation, either as plaintiffs or defendants. These three are virtually in control of the Southern Idaho electrical field and are bitter rivals. The complaint of the Wendell trustees alleged that the Great Shoshone & Twin Falls Co. was serving electrical energy to the towns and cities of Mountain Home, Glenns Ferry and Gooding at a lower rate than to consumers of Wendell. The Great Shoshone Co. denied this and alleged that the Idaho Light & Power Co. and the Beaver River Co., which are serving the same cities and towns and are its rivals, are doing so at a loss. It also charged the two latter companies with instituting the complaint.

Recent Court Decisions

Digested by A. L. H. STREET

Reservation of Title by Seller of Machinery—Where a stationary engine is sold to a contractor, the seller knowing that it is to be installed by the contractor in a power plant, is not entitled to reclaim the engine from the owner of the plant after it has been so firmly affixed to the plant that it could not be removed without injury to the premises, although the engine was sold under a contract providing that title should remain in the seller until payment of the price; the owner of the plant having paid the contractor 90 per cent. of the value of the engine, without knowing that the seller had so attempted to secure payment of the purchase price. (Iowa Supreme Court, Hooven, Owens, Rentschler Co. vs. City of Atlantic, 144 "Northwestern Reporter" 635.)

SOCIETY NOTES

On Jan. 29 the American Institute of Boiler Inspectors held its meeting at the Engineering Societies Building, New York City, and elected the following officers for the ensuing year: President, James Gillespie, Royal Insurance Co., vice-president, Robert Thomson, Travelers Insurance Co.; secretary, J. H. Pollard, Fidelity & Casualty Co.: treasurer, George Turnbull, Globe Insurance Co. James H. Kinkead was elected chairman of the executive and educational board. The Institute will hold its annual dinner on Feb. 21, and every effort is being made to have the occasion exceed all former dinners.

The first annual convention of the Mountain States Ice Manufacturers' Association was held at the Albany Hotel, Denver, Colo., Jan. 22-23. Among the papers read and discussed were "Vail's New Type Cylinder Condensers," H. G. Venemann; "Side Lines for Small Plants," J. F. Vandermark; "Raw Water Ice," James Allan. On Thursday morning, Jan. 22, the members visited the plant of the Colorado Ice & Cold Storage Co., and inspected the largest storage room in the world holding manufactured ice. In the evening there was a theater party. A visit was made on Friday to the ammonia works of the Western Chemical Co., which tendered the visitors a luncheon. At 6:30 there was a banquet at the Albany Hotel.

The first annual meeting of the Compressed Gas Manufacturers' Association was held on Thursday afternoon, Jan. 29, at 25 Madison Ave., New York. The retiring president in a brief address reviewed the activities of the association during 1913, and reports from standing and special committees were submitted and read. The following were elected as the executive board for 1914: J. B. Greiner, J. C. Minor, Jr., A. A. Heller, Justin G. Sholes, Hugo Lieber, C. J. Lilienthal, H. E. Sturcke, W. A. Johnston, G. McM. Godley, Eugen Becher, Geo. S. Haydock, J. T. Stewart, Otto S. King, A. Cressy Morrison, Franz Hirschland. The board subsequently organized and elected as officers for 1914: President, Hugo Lieber; first vice-president, J. B. Greiner; second vice-president, A. Cressy Morrison; secretary and treasurer, John J. O'Rorke. The outgoing executive board entertained the members of the association at an informal dinner at the Manhattan Club, Twenty-sixth St. and Madison Ave., in the evening; covers were laid for 60. Dr. Hugo Lieber presided.

PERSONALS

L. B. Stillwell, New York City, has been named by the Secretary of the Treasury as consulting engineer in the construction of a government power plant for Washington, D. C., to cost $1,500,000. It will furnish light, heat and power to all government buildings, including the White House.

Walter E. Housman and Hans E. Seidl have formed a partnership to operate under the name of Seidl & Housman, 901 Swetland Bldg., Cleveland, Ohio. The firm will do a consulting engineering business along the lines of public utility work and mechanical and electrical engineering. Mr. Housman was for many years power expert with the United States Steel Corporation and Mr. Seidl has been associated with public utility work as consulting engineer for a number of years.

Harold Almert, for the past five years manager of the department of examinations and reports of H. M. Byllesby & Co., has severed his connection with that firm to engage in consulting engineering practice on his own account, with offices in The Rookery, Chicago, Ill. Mr. Almert is just completing his twentieth year of work in the organization, financing, design construction, operation and management of public utilities, and for several years has valued or passed on investments for new projects, consolidations, reorganizations or extensions to existing properties of from one to two hundred million dollars, annually. As assistants Mr. Almert will have a staff of well seasoned specialists in mechanical, electrical, hydraulic and gas engineering, appraisals, rate investigations, accounting and efficiency work who, by their training and experience, are experts.

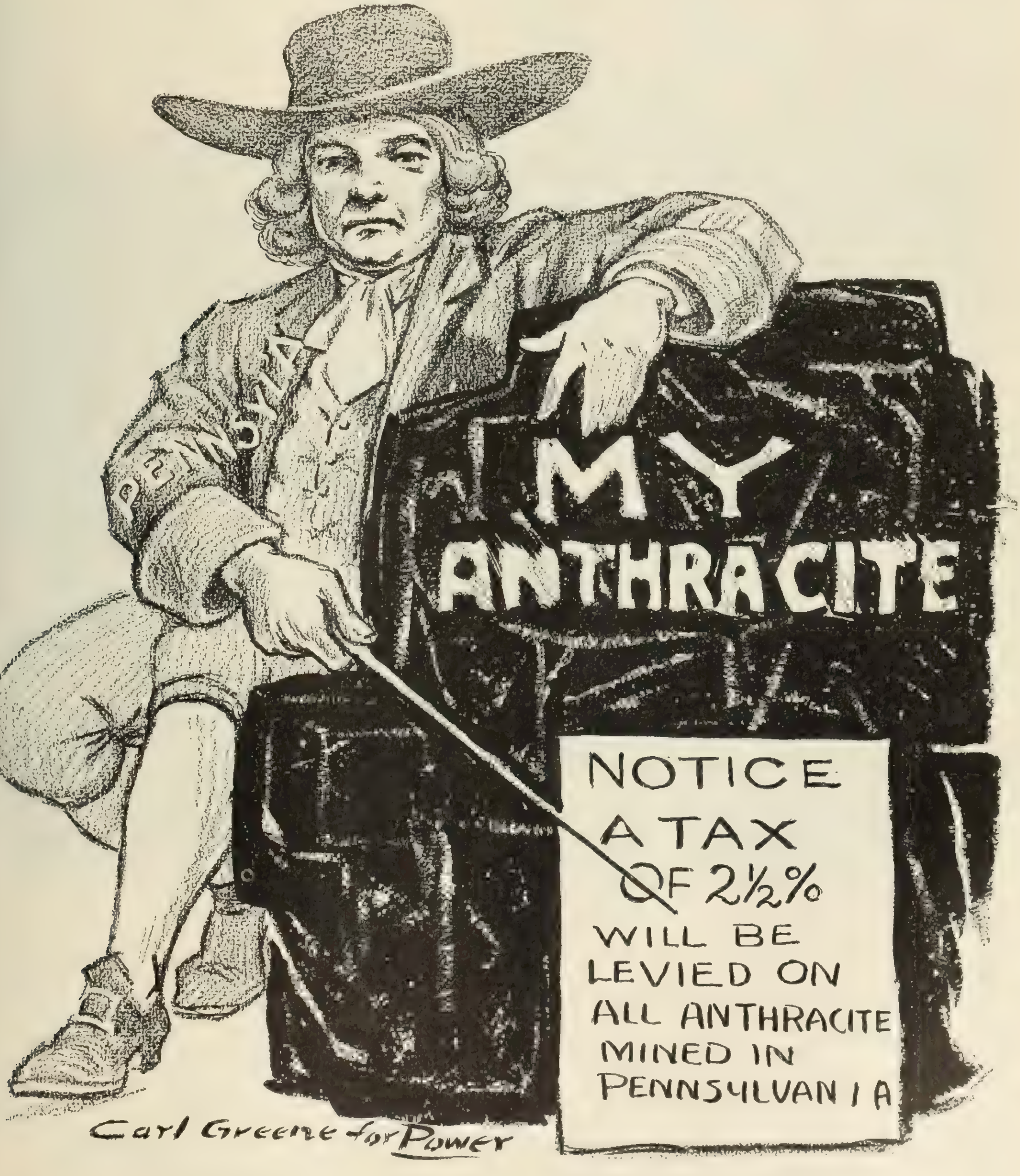
NEW PUBLICATIONS

COAL WASHING IN ILLINOIS. By F. C. Lincoln, of the department of mining engineering, has just been issued as Bulletin No. 69, by the Engineering Experiment Station of the University of Illinois.

A great amount of data, gathered from experiments made in the mining laboratory of the university, personal visits to the various coal washeries in the state, and a thorough search of the scattered literature on the subject, have been compiled and tabulated. The bulletin also contains an article by S. W. Parr, "Moisture in Washed Coals," and is a summary of tests made at the experiment station on carload lots of various washed coals. Copies of Bulletin No. 69 may be obtained upon application to C. R. Richards, acting director of the Engineering Experiment Station, University of Illinois, Urbana, Ill.

POWER

Vol. 39 NEW YORK, FEBRUARY 24, 1914 No. 8



IS THIS BENIGN OLD GENTLEMAN TURNING INTO A SHYLOCK?

Butler Mill Mixed-Pressure Steam Turbine

By Warren O. Rogers

SYNOPSIS—Due to the installation of a mixed-pressure turbine, one 1250-kw. engine-driven generating unit has been shut down and the number of boilers under steam decreased. The turbine and one reciprocating unit generate an electrical output approximately equal to that of the two 1250-hp. reciprocating units.

* * *

If a visitor to the power plant of the Butler Mill, New Bedford, Mass., should mention mixed-pressure steam turbines to Thomas Quinn, chief engineer, an enthusiastic interest would at once be manifested. And with reason, because of the satisfactory results that have been obtained from such a unit in this mill power plant.

The original units in this plant consisted of two 21 and 52 by 42-in. vertical, cross-compound engines, with a speed of 133 r.p.m. Each unit is directly connected to a 1250-kw., alternating-current generator, delivering three-phase, 40-cycle electrical energy to the mill motors. Ten vertical boilers supplied steam to the engines, at 165 lb. pressure. Because of the much stricter structural requirements of the recently enacted state boiler laws, the boiler pressure was reduced to 140 lb., which is now carried. With this reduction it was necessary to operate 10 boilers. The growing power requirements of the mill made the load so heavy at peak loads that it was difficult to keep up the desired steam pressure, and consequently, the speed of the engines was occasionally reduced. This, for a few moments, made a decrease in the output of the mill products. In addition, the management desired more power to provide for increased loads on the power plant when contemplated changes were made.

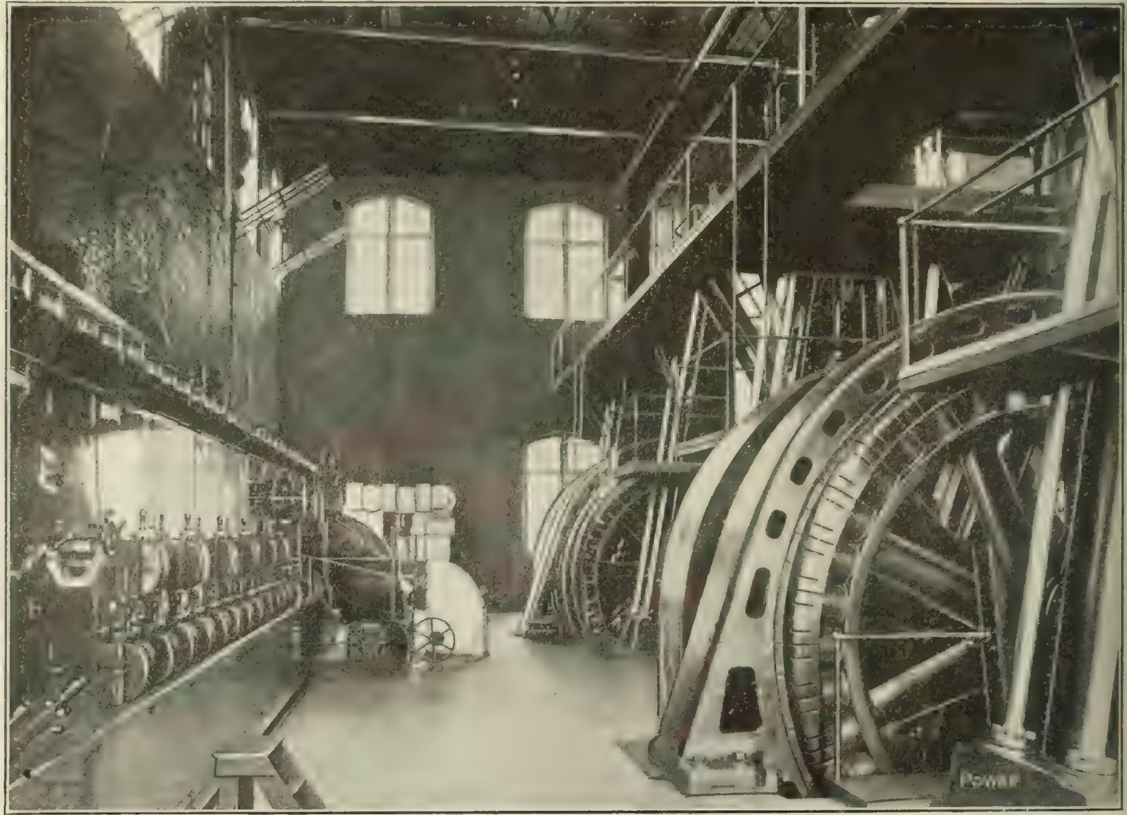


Fig. 1. Engine Room, Showing the 1250-Kw. Mixed-Pressure Turbine and the Two 1250-Hp. Reciprocating Units, One of Which Has Been Shut Down

It was at first planned to put in additional boilers, but after investigation the management decided to install a 1250-kw. Curtis mixed-pressure turbine and use the exhaust steam from one of the reciprocating units, Fig. 1. The turbine is designed to operate condensing on steam at from 16 to 165 lb., absolute. The turbine exhausts to a Bulkley injector condenser, Fig. 2, at from 28 to 29 in. vacuum, and is directly connected to a 1250-kw., 600-volt, three-phase, 40-cycle generator, Fig. 3. The generator of the turbine and that of the reciprocating engine are operated in parallel.

The reciprocating engines were connected to barometric condensers. One condenser was discarded with the installation of the turbine, but the other engine and condenser, which are shut down, can be used if the power demand exceeds the capacity of the engine-turbine units.

Another alteration was that of changing the ratio of the engine cylinders from 21 and 52 to 24 and 42 in., the stroke of 42 in. remaining the same. This was done by putting on a new high-pressure and bushing the low-pressure cylinder.

The reciprocating boiler-feed pumps were replaced by a turbine-driven centrifugal pump, the water going to the boilers at 212 deg. F. The water for the injector condenser is delivered by a turbine-driven centrifugal pump. The exhaust steam from these auxiliary turbines is used for heating the boiler-feed water, but, if desired, the exhaust steam can be sent to the turbine. Salt water from the harbor is used in the condenser. The condenser injection-water pump has a capacity of 1000 gal. per min. against a 42-ft. head running at 1150 r.p.m.

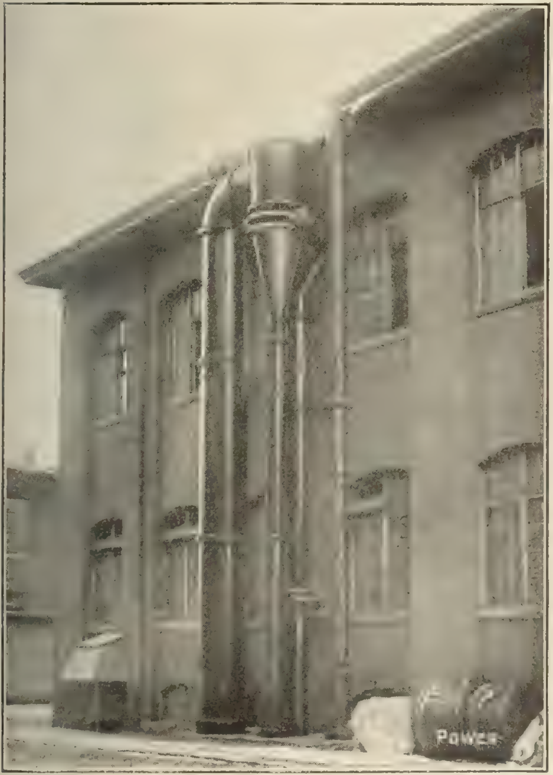


FIG. 2. INJECTION CONDENSER USED WITH MIXED-PRESSURE TURBINE

Before making these changes it was figured that by so doing the necessity of installing additional boilers, another engine and a generator, and the condensing equipment would be eliminated; that some of the original boilers could be cut out of service, and these expectations have been realized.

At the time of the writer's visit to the plant, one of the engines was shut down. There were eight boilers under steam, although during the summer months six boilers will generate sufficient steam for the reciprocating and turbine units. The two extra boilers are necessary in heating the mill. In case the reciprocating engine should break down, the turbine can be operated on high-pressure steam and the idle engine can be operated as formerly.

The installation and operation of the mixed-pressure turbine and shutting down one engine have resulted in saving fuel, especially during the summer months, when four of the ten boilers are cut out of service. The boiler-room labor and the cost of lubricating the idle engine are also decreased. Under the old conditions, it was necessary to operate the boilers under induced draft, and then there was difficulty in keeping up steam; now they run under natural-draft conditions, with a reduction in the number of boilers and at a lower steam pressure.

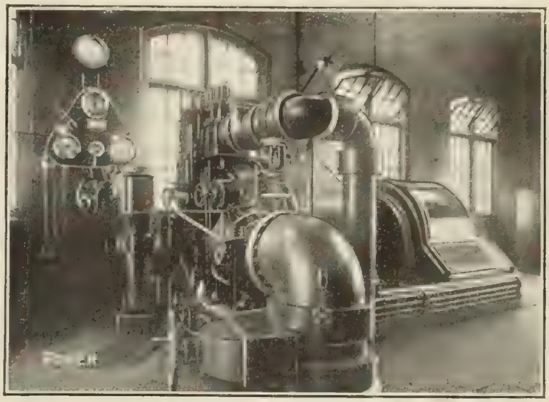


FIG. 3. COMPACT 1250-KW. MIXED-PRESSURE TURBINE

The output of the two reciprocating engines, with full load, was approximately 2500 kw., with a normal load of about 975 kw. each. The load at the switchboard on the one engine and generator was 975 kw., the day of the writer's visit, and the turbine unit, using steam that had already developed this electrical output, was generating 925 kw., a load almost equal to that on the engine unit.

The success of this turbine-and-engine combination will be watched with interest by other mill men of New Bedford, as the Butler mill plant is the first and only one in the city in which a low-pressure turbine has been installed.

Some Mechanical Kinks to Prevent Clinkering

Where a coal clinkers badly on account of the sand and the bases being nearly balanced, the fusing point of these impurities can be raised by adding some more bases. Hence, to hinder the clinkers forming or prevent it entirely, add some limestone, magnesia rock or oyster shells, to the fire. Numerous schemes have been tried by firemen and engineers to prevent clinkers and considerable improvement has been made in late years in burning coal in boiler furnaces, especially in the use of the finer sizes and the refuse coals, or culms as they are sometimes called. Engineers who are giving special study to the problem of coal burning believe that further improvement is possible. Some of the refuse coals contain a great deal of sand, clay and iron, and clinker badly if burned in the old way.

One of the first clinker preventives tried on this class of fuel is the steam blower. This was used because it was easy to apply and "it does the work." Its virtue lies in its cooling action on the fire bed, for with some coals the higher the temperature of the fuel bed the greater the tendency to clinker. There is also a chemical action when water vapor passes over red hot carbon. It must be remembered, however, that water is not a fuel, and for this reason many of the engineers who have advanced ideas on coal burning have insisted on the development of some other method both for making draft and for clinker prevention. In this they have been quite successful by using a special method of starting and cleaning the fires and by using a small air space and a high-pressure air blast. In starting the fire, plenty of kindling is used so as to make an evenly distributed fire and one that is brought up slowly. An ash bed is formed and kept over the entire grate.

If any clinkers form, even if very small ones, they should be removed when first cleaning the fire, as these little clinkers shield small areas of the fuel from the air blast and the clinker will continue to grow. The air distribution must be uniform. As to the air space in the grate, the old theory was to use a grate having the maximum air space which would at the same time prevent the fuel from falling through. This requires a relatively low draft pressure. The new plan is to reduce the air space, as much as 50 per cent. in some types of furnace, and to increase the blast. The effect where properly installed and operated has been remarkable. The high velocity of the blast through $\frac{1}{16}$-in. holes with 3-in. blast, and with a Dutch-oven furnace produces an intense furnace temperature. Under these conditions it is possible to keep a white heat in the furnace and at the same time have the grates free of clinker, and this, too, when burning a refuse coal that clinkers very badly if burned in the ordinary manner.

The size of the holes in the grates has a great deal to do with clinker formation. This applies both to the steam jet and to the air blast. A case is on record where four boilers of the locomotive type were fired by the same men and with the same coal, yet three of the furnaces clinkered badly and one did not. Steam jets were used in the ashpits. The difference lay in the grates. The three furnaces had $\frac{3}{16}$-in. holes, and the fourth one had $\frac{1}{8}$-in. holes. The latter, therefore, had been given more steam to obtain the desired rate of combustion, and had an air blast been used, it is likely that the grates having the smaller holes would have proved the better for preventing clinkers, because a stronger blast could have been used than would have been allowable with the larger grate openings.

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Economical Burning of Fuel*

SYNOPSIS—Some practical points tending toward economy in the burning of oil, lignite and slack coal under boilers.

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Oil Fuel

With fuel oil, which is high in carbon and quick to burn, the requirements are plenty of air at as near atmospheric pressure as possible; a thorough atomization, using as little steam as is necessary for the purpose, and just sufficient draft to pull the gases out through the boiler at the proper velocity, never over 0.10 in. of water in the uptake and less in the furnace. Have a large combustion chamber with no bridge-wall to retard the gas flow.

To control the draft it is necessary to use a damper in the uptake. Consider first that on full load there is a draft of 0.10 in. If the load drops, then the damper should be closed accordingly. The serious drawback to the common method of firing with oil is that a heavy draft is maintained on the entire furnace setting, causing an infiltration of cold air which dilutes the gases and reduces their temperature. These conditions prevail where the ashpit doors are used to control the air supply. These doors should be taken off when burning fuel oil.

When several boilers are under steam at a time, each one should be equipped with a draft gage, located in the uptake just below the damper; the dampers should be manipulated so that each gage registers the same draft pressure. This insures a uniform load for each boiler, provided that the furnaces are equally fired.

The approved type of oil burner spreads the oil fuel in a fan-like spray over the grates, which have been paved with firebrick arranged so that openings of about $\frac{1}{2}$ to $\frac{3}{4}$ in. are left between them. The edge of the spray should come just to the side walls, so as to fill the combustion space with a well mixed and nonstratified gas. Always use a burner of sufficient size to fill the full width of the boiler setting and never try to operate one side at a time; use both or all burners, but reduce the capacity by the needle valve when full capacity is not required. Leave a clear space of 1 in. or more between the side walls and the grate pavement, thus permitting cold air to enter and prevent burning out the side walls. The use of target walls is not advisable.

The average fuel oil, as sold in Texas, has 18,600 B.t.u. per lb., the average steam pressure is 125 lb. and the feed-water temperature 208 deg. F. Under these conditions, the evaporating capacity of this oil per pound at 100 per cent. efficiency is 18.3 lb. of water from the temperature given. With a combined efficiency of furnace and boiler of 70 per cent., an evaporation of 12.8 lb. of water per pound of oil burned may be expected. This efficiency might be maintained with a load ranging from 75 to 125 per cent. of full load. For less or greater loads a combined efficiency of 70 per cent. could not be expected. At one-fifth load the efficiency would range from 55 to 65 per cent. and the evaporation from 10 to 11.9 lb., a reduction of 22 per cent. in fuel economy at the lower efficiency. This shows conclusively the importance of operating the boiler plant at as near full load as possible.

Never permit the fireman to work six boilers when the load is just sufficient for five, though he will protest against the full load on the five boilers because closer attention is required.

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*Abstract of paper read by J. P. Greenwood before the Practical Refrigerating Engineers' Association, at Dallas, Tex.

Each boiler has certain peculiarities and must be studied as an individual patient. To determine the proper draft pressure for any certain boiler at different loads, it is necessary to use a CO_2 instrument and regulate the damper and burners for the load so as to secure the most desirable percentage of CO_2 in the furnace gases, which is 14 per cent. when the lowest uptake temperature consistent with draft pressure is obtained. The temperature should be taken just as close to the end of the gas pass as possible.

When the furnace gases are an orange color, never under any circumstances a dazzling white, the correct burner and the proper air mixture have been secured. As the draft determines the quantity of air the importance of the draft gage will be apparent.

In burning natural gas **only,** the furnace construction and burner equipment will be different. Have as high gas pressure up to the burner exit as possible. Regulate the burners to obtain the proper mixture. In handling fluctuating loads, turn the burners on or off, but do not change the mixture.

Texas Lignite

This fuel exists in great abundance in Texas and the supply will undoubtedly last for centuries. When the price is not prohibitive it is a desirable fuel. It is low in heat-value and therefore requires considerable handling, as more of it must be used to carry the same load.

The average lignite in Texas runs about 7600 B.t.u., and on the same conditions given for oil, it has an evaporative capacity of 7.5 lb. at 100 per cent. efficiency. The average furnace and boiler when burning lignite will have a combined efficiency of about 50 per cent., or an actual evaporation of 3.75 lb. of water per pound of lignite.

In firing lignite at the normal rated load in hand-fired furnaces, the author found that the furnace doors were open for stoking about 15 per cent. of the time. During this period the combined efficiency of the plant is not over 30 per cent. at best, so that it is important to reduce the time of firing as much as possible.

The commercial boiler settings and grates sold in Texas are not adapted to the economical use of lignite. This fuel contains from 15 to 40 per cent. of water; when the moisture is gone the binding quality is removed and the lignite is harder than ever to fire, because it slacks similar to lime and becomes a powder which fills the air channels through the fuel bed and effectually cuts off the draft. Its volatile component forms 20 to 30 per cent. of the fuel, and being a hydrocarbon it is easily distilled when the fuel is first admitted to the furnace. If there is sufficient air and high enough temperature in the furnace, this volatile matter will be burned; otherwise, it will be deposited in the tubes as soot. The farther away the furnace is from the boiler tubes or sheets, the better are the results obtained. The furnace should be about 6 or 8 ft. away from the tube sheet, say in a dutch oven, or lower down than usual.

A half-dutch oven setting for the use of lignite is recommended. A setting with a 2½- or 3-in. air space left between the inside and outside walls, which is filled with equal parts of sand and ashes, is good construction. When a crack develops in the side walls the sand and ash mixture will tend to close it and prevent the air from leaking into the furnace. With a steel casing, be sure that plenty of nonconducting material is used between the brick lining and the casing; otherwise, the heat losses from radiation and conduction will exceed those of air infiltration in the case of a brick setting.

The bridge-wall should be just high enough to prevent the fuel from falling over into the combustion chamber; it has no other function. It is a mistake to build a high bridge-wall and curve it with the boiler, as this simply chokes the gas travel and causes the draft pressure to pull too much cold air through the setting. Natural draft is the most satisfactory.

With a stack of sufficient height to produce a draft of 0.8 in. of water in the uptake and a 150-hp. boiler with 1500 sq.ft. of heating surface to evaporate 4500 lb. of water into steam per hour at 50 per cent. combined efficiency, and an evaporation of 3.75, it is necessary to fire 1200 lb. of lignite per hour. With the average grate area of 25 sq.ft., this is burning 48 lb. of lignite per square foot of grate per hour, to maintain normal capacity. The draft pressure should be about 0.5 in. of water, depending upon the size of the lumps and the amount of slack in the lignite.

On the other hand, the grates may be 6 ft. long, giving a total of 30 sq.ft. of surface. In this case only 40 lb. of lignite per sq.ft. of grate surface would be burned, the fuel bed being about 12 in. thick. Suppose only half load was demanded, then 20 lb. of lignite per sq.ft. of grate must be burned and the draft lowered to secure the best results; but unless the damper is manipulated there will be practically the same draft pressure at all loads. The foregoing emphasizes the necessity of a properly installed draft gage and damper. It would be well to put a draft gage on the uptake and on the furnace. The furnace gage would indicate the resistance to the air through the fuel bed, while the one on the uptake would show the resistance through the boiler tubes.

Lignite calls for a large combustion chamber, so that the volatile matter will have a chance to burn before coming in contact with a comparatively cold surface. A shaking grate with as many small holes as practicable, the percentage of air space being not less than 20 and not more than 30 per cent., is the most desirable type for a hand-fired lignite furnace. Do not make the mistake of getting a large grate surface with 30 to 50 per cent. air opening, and have the proportion of grate area to heating surface 1 to 50 or 1 to 60. If it is a question of capacity, add to the stack and use a thicker fuel bed. Lignite requires little slicing or, on a shaking grate, shaking, but an attendant should slightly move the grates every ten or fifteen minutes, depending on the load on the boiler.

The alternate methods of firing and of cleaning fires is the best system. When cleaning, close off the dampers on the boiler. With a good practical shaking grate, lignite fires may not need cleaning oftener than once in six hours at full load. To establish the proper draft pressure for lignite fires it is necessary to use a CO_2 instrument, and determine the pressure when the gases show about 14 per cent. CO_2. This will be about one minute after stoking the furnaces, and from this instant until the fires are again stoked the CO_2 will gradually drop down to as low as 4 or 5 per cent. A study of the furnace conditions will determine the firing intervals for best results. The CO_2 sample may be taken over a period of twelve hours or more by using a sampling tank, and making a daily analysis of gas; this will give the average for the time or day of sampling. When the highest average has been established and the draft gage noted, then it is a question of watching the draft gage and regulating the furnace accordingly.

In buying a new boiler always use an 18-ft. tube, or longer, and in water-tube boilers above 300 hp. a double pass for the gases is preferable.

SLACK COAL

To burn this fuel economically a furnace similar to one for lignite is desirable, the same general conditions will apply. An automatic type of flue blower would be advantageous, as blowing the tubes when using slack coal is beneficial. Slack coal should be fired in small quantity and evenly spread over the grate surface, and not over 5 to 8 in. thick. If the slack has a tendency to cake, it must be sliced frequently to secure the best results; do not break up the fuel zone, simply run the slicebar under the fuel bed on top of the grates and give it a slight twist and side movement so as to open up air holes.

A shaking grate with 40 per cent. air space will be satisfactory and a tall stack and a strong draft are desirable. A shaking grate should be oscillated every 10 or 15 min., or whenever the ashpit grows dark and no reflection of light from the grates is seen.

Never rock a grate violently, as it does more harm than good. Never use a long grate bar, as the average fireman will not keep the back of it covered, and excess air leaking through and diluting the furnace gases is a serious matter. It may be considered necessary to have a long bar in order to get the desired capacity, but it is better to add more to the stack at any cost, and save fuel thereby in having a stronger draft, a deeper fuel bed and less loss. It is the draft pressure that is largely responsible for the ultimate economy.

A water-tube boiler is slightly more efficient than the horizontal return-tubular type in equal capacities when burning lignite or slack coal, but there is practically no difference when using oil or gas fuel. With a horizontal water-tube boiler a horizontal baffle is preferable and more practical than the unreliable vertical baffle.

* * *

Recording Meter Measuring Boiler Blowoff Discharge

A unique use to which the "Lea" V-notch recording meter has been put is in the measurement of the blowoff discharge at the Waterside station of the New York Edison Co. The arrangement is shown by Fig. 1.

Continuous measurement, showing operating conditions of the different factors of the power plant, is becoming more universal in American power plants. It has been the practice for some time to measure boiler-feed water continuously so that the evaporative value of the coal and the efficiency of the boilers can be determined. In many plants continuous records of condensate from individual units are made by which the steam consumption per kilowatt can be compared with previous records. As far as known, however, this is the first case where continuous record is being made of the intermittent boiler blowoff discharge as well as of the blowoff leakage.

Such a record enables the engineer to determine the amount of water evaporated per pound of coal or per kilowatt, because by measuring the makeup water continuously and subtracting from this quantity the blowoff discharge, an exact quantity is left which represents the amount of water evaporated. The total boiler feed in some plants is determined by measuring the makeup water to the heaters, to which is added the condensate from each of the turbine units, equipped with surface condensers, and from this total is deducted the heater overflow and the blowoff discharge.

In the measurement of blowoff discharge there are peculiar conditions, but the recording meter is adapted to meet them because it is accurate at low rates of flow as well as high. Blowoff discharge from a given plant is a fluctuating quantity because the boiler-staff may blow down a series of boilers in the morning and then do no further blowing down for 12 or perhaps 24 hr. In the interim, the only water flowing through the blowoff discharge is the leakage from defective blowoff valves. This latter quantity is small in a well run plant, yet it is important for the engineer to have a chart record of this small quantity.

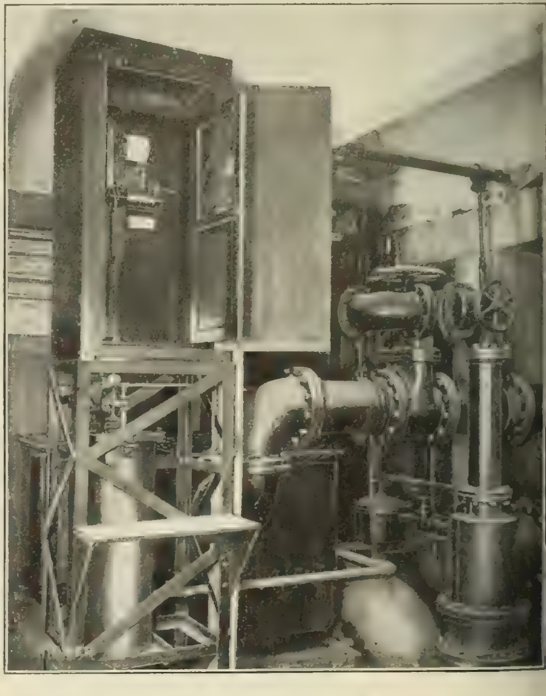

FIG. 1. V-NOTCH RECORDER FOR MEASURING BOILER BLOWOFF DISCHARGE

The system as installed consists of a heavy steel V-notch tank with a sealed cover vented to the atmospheric exhaust line, Fig. 2. The tank is provided with a partition which contains the weirs. To one side of the tank is placed the float chamber, connected to the central section of the tank, by means of a $2\frac{1}{2}$-in. pipe with a valve for throttling purposes. The recording instrument is supported on a steel frame over the float chamber. The top of the float chamber is vented over to the top of the weir tank. The float spindle passes through an anti-vapor gland in the float-chamber cover, thence up through the instrument base where another anti-vapor gland is provided to prevent steam rising into the instrument. Here the float rod connects with the instrument rack and operates the recording drum on which is graduated the rate of flow. The slider bar of the instrument transmits to the pen the instantaneous rate of flow and the clock drum revolving draws a curve which is the curve of flow of the water passing through the weirs.

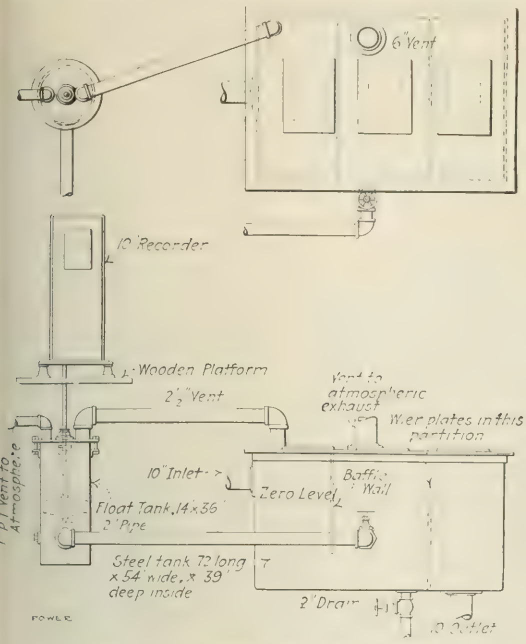

FIG. 2. V-NOTCH TANK AND PIPING

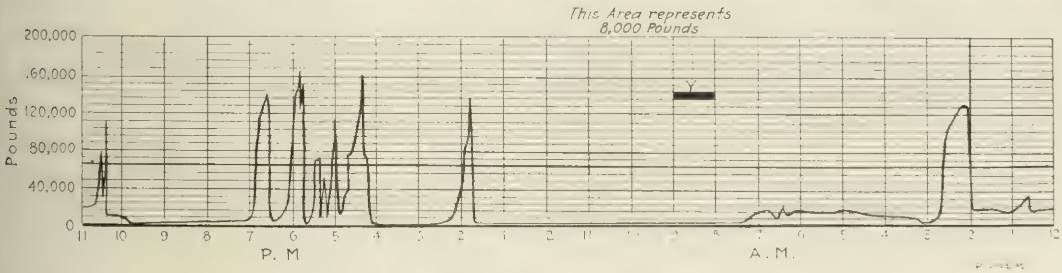

FIG. 4. CHART FROM V-NOTCH RECORDER

The inlet enters one end of the steel tank from a connection to the blowoff tanks of the plant, and the blowoff tanks are vented so that there is practically no pressure accumulation in the V-notch tank. If there is such an accumulation, a large 6-in. vent relieves it. The discharge from the blowoff tank goes to the sewer.

To increase the range of the recorder two weir plates are used, one of which is a standard one-quarter 90-deg. V-notch (i.e., having one-fourth the capacity of a 90-deg. V-notch), while the other is a rectangular weir whose zero line is elevated 6 in. above the zero line of the V-notch. Water will, therefore, pass through the V-notch until a 6-in. head is passing when the water will begin to flow through the rectangular weir and as the flow increases both weirs will take care of the discharge.

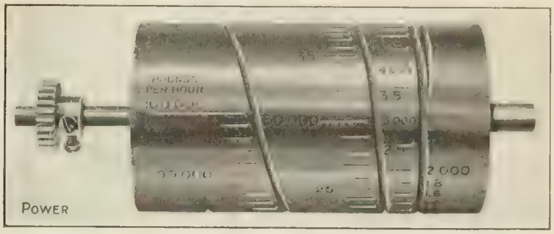

FIG. 3. DETAILED VIEW OF THE CAM DRUM

The recording instrument is provided with a cam drum, Fig. 3, cut for the flow through the one-quarter 90-deg. V-notch. In other words, it is a $^5/_2$ curve. By consulting the accompanying chart, Fig. 4, there will be noted a second datum line which represents the zero line of the rectangular weir. To determine the quantity of water which has passed through the weirs it is necessary to planimeter first the area within the curve and then multiply this by the value of 1 sq.in. of the chart, which is the constant of the chart. Then planimeter the area of the peaks of the curve above the datum line corresponding to the zero level of the rectangular weir and multiply this area by a constant, which has been predetermined by the flow over the rectangular weir. These two quantities are added together and represent the total blowoff discharge.

Although the curve of flow of the rectangular weir is a $^3/_2$ curve and the curve of the flow over the V-notch is a $^5/_2$ curve, when comparing at and above the datum line above the rectangular weir, they closely resemble each other; hence the small error introduced by the $^5/_2$ cam of the recorder is negligible.

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Contract for Panama Exposition Buildings—Contract for the construction of the Palace of Arts and the Palace of Government, two of the reinforced concrete buildings for the Panama National Exposition, have been awarded. The buildings are to be completed by October 1, 1914. The two together will contain over 8000 electric lights.

Difficulties of Transporting

By Alfred Gradenwitz

SYNOPSIS—Some interesting cases illustrating the difficulty of transporting heavy machinery where the needed facilities are lacking or are rendered useless.

Present tendencies of designing central stations for supplying power to large districts and of concentrating their output in a few mammoth generating units, have given rise to transport problems, not always sufficiently appreciated. Some striking instances, for which the writer is indebted to an engineer of Sulzer Brothers, of Winterthur, Switzerland, are given in the following:

In large cities, where transportation is greatly facilitated by rail or by waterways, the erection troubles encountered are relatively easy to overcome. Where conditions are different, transportation may prove so difficult and expensive as to stand in the way of the realization of the whole scheme. In connection with an installation in the Argentinian Cordilleras, the cost of transport rose to enormous figures. Even the masonry walls entailed ten times the usual price. In such cases the bricks have frequently to be conveyed great distances by mules, or by camels, as in Egypt (Fig. 1).

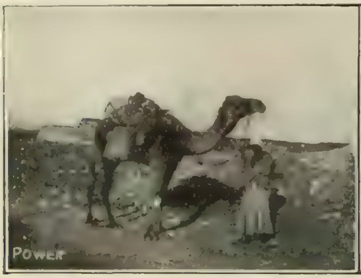
FIG. 1. TRANSPORTING STONES BY CAMEL

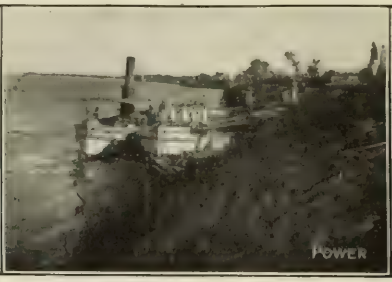
FIG. 2. TRANSPORTATION ON THE NILE

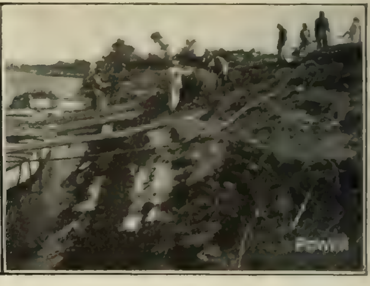
FIG. 3. LOWERING A SULZER FLUE BOILER

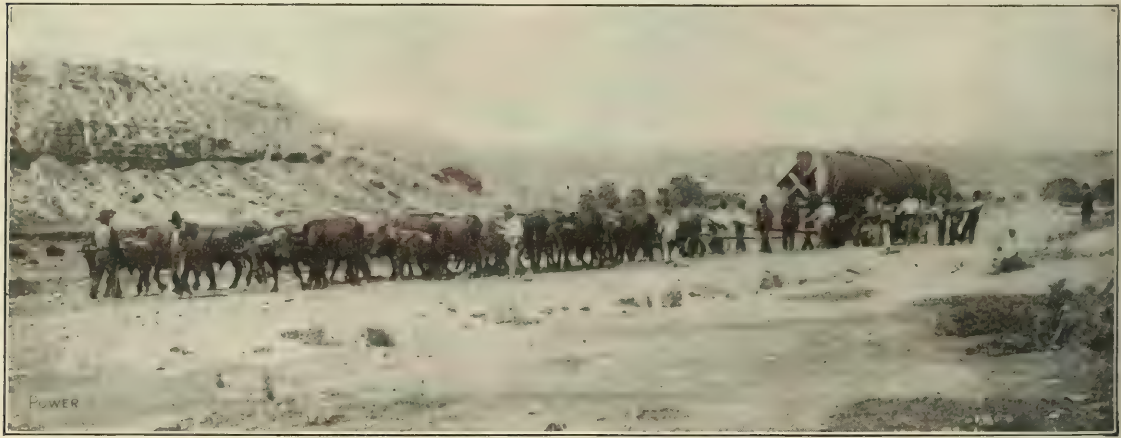
FIG. 4. OXEN AS THE MOTIVE FORCE

The absence of cranes, winches, trucks of sufficient capacity, etc., may compel the engineer to invent new methods. As an example, large boilers, and even gas tanks, have, like ship hulls, been floated by their own buoyancy on rivers or at the seacoast from one place to the other. This course must be adopted in the absence of transport vehicles of sufficient size, or when they cannot come close to the unloading station. Such remarkable sea trips have been made by some Sulzer fire-tube boilers installed at the lead and silver mines of Almagrera, Spain, near the Mediterranean coast. Since the transport of such big pieces from the nearest railway station to the mines would have entailed extraordinary difficulties, the waterway was chosen in spite of the absence of any harbor accommodation or even a landing bridge. Since the boilers, on account of their mechanical strength, could pass the breakers without any danger, they were readily hauled to the coast from the transatlantic steamer anchored at the roadstead. In a similar case it was possible to drag the floating Sulzer boilers up on an emergency runway made of planks and rollers by means of a shunting locomotive, as the rails reached fairly close to the coast. Figs. 2 and 3 show boiler transportation in Egypt, on the banks of the Nile.

Interesting conditions are frequently met with in countries of small population, considerable distances and lack

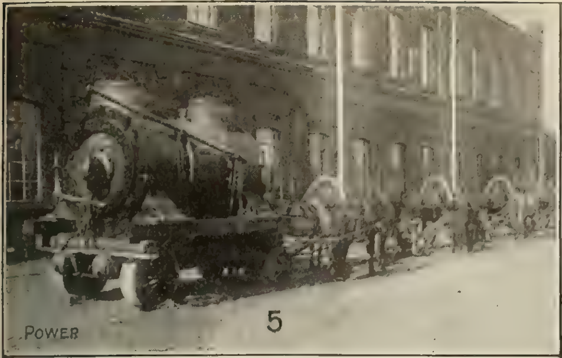

Fig. 5. Hauling an Engine Cylinder in Russia
Fig. 6. On a Swiss Mountain Road

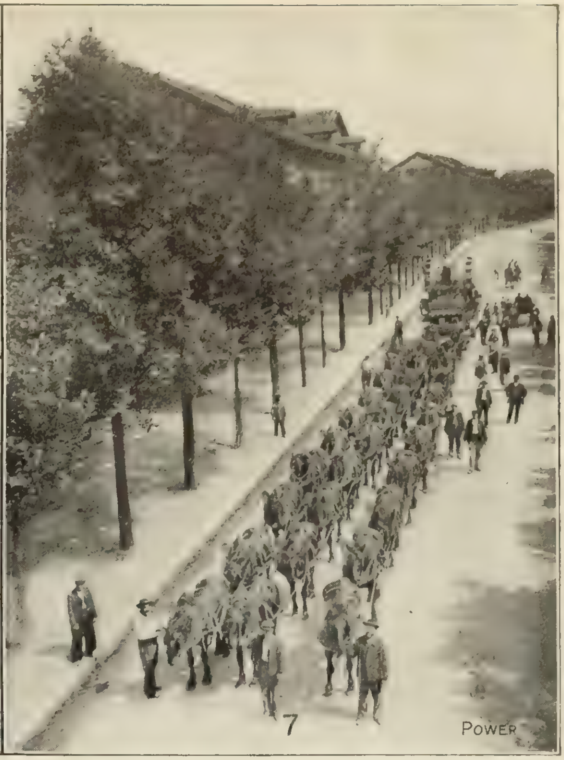

Fig. 7. Transporting a Turbine Casting in a Suburb of Paris

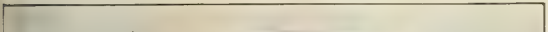

Fig. 8. Moving an Engine Cylinder on Trestles along the Thames

f railways and waterways. Such countries may not be-ome industrial districts, though industries may develop n account of the necessity of exploiting some treasures f the soil. As mines, spinning mills, corn mills, etc., are found in the most out-of-the-way countries, it is often necessary to convey machinery of considerable dimensions and weights on trucks over country roads.

Such a transport is illustrated in Fig. 4. This mine was not of sufficient size and output to warrant the installation of railway lines. The roads in these countries generally leave much to be desired; the trucks often sink to the axle, and the bridges over the rivers are usually not strong enough to support heavy objects. In transporting a heavy Sulzer steam engine destined for a spinning mill in the interior of Russia, bridges had to be constructed specially for the purpose.

Such transport work is frequently made even more difficult by the lack of unskilled workmen, although this deficiency may be made up by numbers. Fig. 5 shows a Sulzer steam engine being conveyed from a Russian custom house to the site of the power house.

Unexpected difficulties may occur in the winter when the rivers are frozen. A disagreeable surprise was experienced in connection with a large steam engine to be conveyed upstream from the mouth of the Dnieper. Since the river was not free from ice and no delay was permissible in fitting up the engine, it had to be taken to pieces, the parts being transported over the country road to the spot, which, of course, took many days.

Such untoward difficulties may sometimes occur in the largest cities. Fig. 7 represents operations in Paris during the transport of heavy pieces belonging to two large 10,000-hp. Sulzer steam turbines and the electrical generators. Since the central station had no siding and at the banks of the river, on which the power house is situated, no crane of sufficient capacity was available to allow the waterway to be used, the engine parts had to be transported on trucks from one of the railway stations through the streets of the city, and a special permit obtained for passing the streets and the bridges across the river. Sunday morning was allowed for the work, which took 6½ hr. Several of the heaviest pieces weighed from 77,000 to 88,000 lb.

Fig. 8 illustrates the difficulties of transport in London. The cylinder shown belongs to a 6000-hp. steam engine. There being no other avenue of approach, the parts had to be taken to the site of the power house on trestles alongside the Thames.

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Solving the Cinder Problem at Waterside--V*

By Charles H. Bromley

SYNOPSIS—This article, the fifth and last describing the cinder abatement at the Waterside stations of the New York Edison Co., treats of the successful cinder catcher, which has been perfected only after years of experimentation. The gases at high velocity impinge first upon a film of water running over a movable baffle in the main flue, at nearly right angles with the boiler uptakes, and then are projected at a velocity of 50 ft. per sec. into water in the bottom of the flue. About 95 per cent. of the solid matter is removed. The water in the flue is used over and over, and after a 24-hr. run contains 0.025 per cent. sulphurous and sulphuric acids. Copper proves the best material for the baffles.

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The New Wet-Process Cinder Catcher

At Waterside No. 2 station six boilers and the 50x90-ft. flue were cut out of service to permit installing the new wet-process cinder catcher, an end sectional elevation of which is shown with the flue and the boiler in Fig. 18.

To one of these main flues six boilers, standing back to back, three in a row, are connected. In the illustration, *A* and *A* are the smoke connections from the boilers to the flue *B*, which has a combined baffle and trough *C* extending the entire length of the flue. Fitting closely to this baffle is a large movable damper *D*, 5x50 ft., extending the length of the flue and poised at such an angle that it comes ordinarily within 3 to 6 in. of touching the side of the flue at *E*, and within the same distance from the surface of the water in the bottom of the flue, the depth of water being about 18 in.

This large damper is counterbalanced by weights through the chain and wheel *F*, the bottom of the damper being held near the flue by the link *G*. In the trough is an 8-in. water pipe *H*, extending the length of the flue and having 1-in. holes spaced at 4-in. centers in the bottom.

Water is taken from the tank by a centrifugal pump, Fig. 19, on the boiler-room floor and raised to the pipe *H*, from which it runs into the trough, overflowing the latter and running in a sheet down over the surface of the baffle *D*, and dropping off (in a sheet) into the tank. About 75 gal. of water per min. per boiler is circulated, and about 8 gal. per min. per boiler is added to make up for that lost by evaporation and spray carried away by the gases.

As the damper *D* is movable and counterbalanced it may be raised or lowered by turning the handwheel *J*; thus when raised, the link *G* will force it away from the side of the flue a distance proportional to that which it has moved above the surface of the water. The fundamental reason for the damper is to increase the velocity of the gases, and the reason for moving it is to allow for increased draft due to increased load on the boilers.

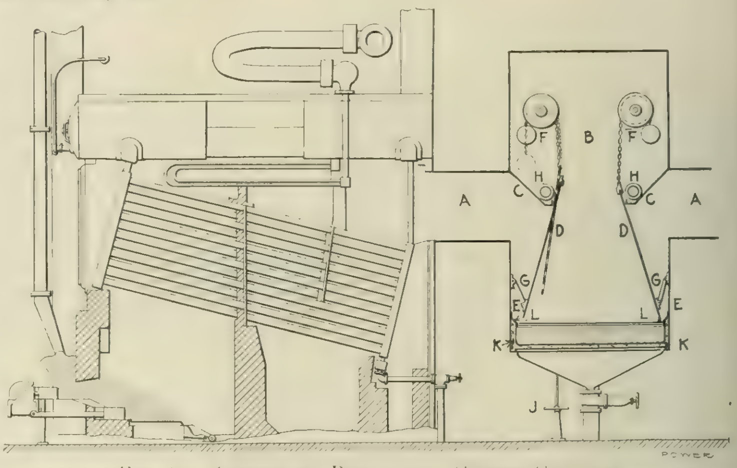

Fig. 18. Section of Boiler and Cinder Catcher

Action of Gases and Cinder in the Catcher

Formerly, the gases passed from the boiler through *A* and into the open flue *B*. Now they come through *A* as before, are deflected downward by the baffle *C*, impinge on the sheet of water on the baffle *D*, and then pass down through the wedge-shaped duct formed by this baffle and the side of the flue. The gases thus attain a high velocity as they rush through the opening at the bottom of the damper. From 10 to 14 per cent. of the cinder is taken out by the sheet of water on the damper, and from 80 to 85 per cent. is removed when it is projected onto the surface of the water with the high velocity attained. This velocity is acquired partly by the increased velocity of the gas current and partly by gravity. This is an important feature, for the inertia of the solid particles varies in proportion to the square of the velocity, and the resistance of the projected particles to any force tending to change their direction of travel varies as the inertia. It is estimated that the cinder is projected toward the surface of the water at an approximate velocity of 50 ft. per sec.

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*The cinder catcher described in this article has been patented jointly by Thomas E. Murray and C. B. Grady, of the New York Edison Co.

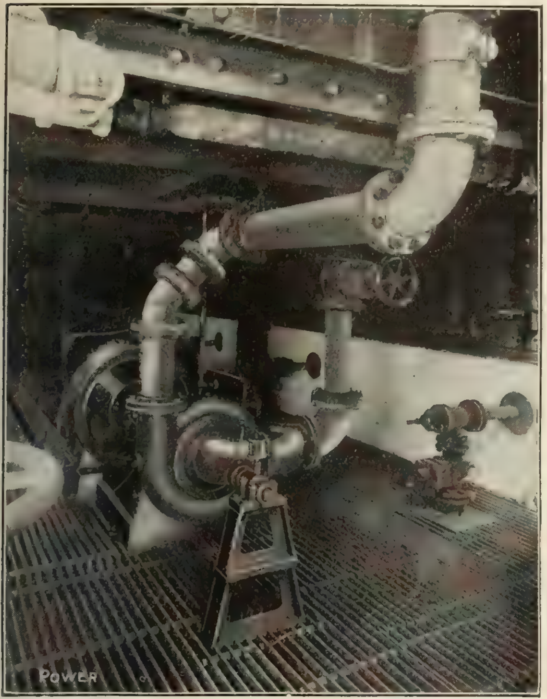

Fig. 19. The Circulating Pump

Effect of Cinder Catcher on the Draft and Boiler Capacity

The cinder catcher does not seriously reduce the boiler capacity. With a draft at the stack base of from 0.9 to 1.2 in. of water a load of 1500 hp. can be carried on each 650-hp. boiler with only a slight decrease in the efficiency of the cinder catcher. The position of the baffle is always maintained, so that the velocity of the gases leaving the baffle is the highest possible with the stack draft obtainable, thus under normal draft conditions, with boilers operating at 110 and 150 per cent. rating, the baffle opening would be from 3 to 6 in. and increased to 14 in. at 225 per cent. rating.

Effect of Acid Water on Baffles

The gases at the Waterside stations contain about 0.06 per cent. sulphur dioxide gases which have a great affinity for water. A certain amount of sulphurous acid and sulphuric acid is formed by the gases coming in contact with the water.

As they leave the cinder catcher, the gases carry away some water in the form of spray, and the water in the tank, after a 24-hr. run, contains about 0.025 per cent. of sulphurous and sulphuric acid. A small amount of hydrochloric acid is also formed by the combination of sulphuric acid and the salt in the water.

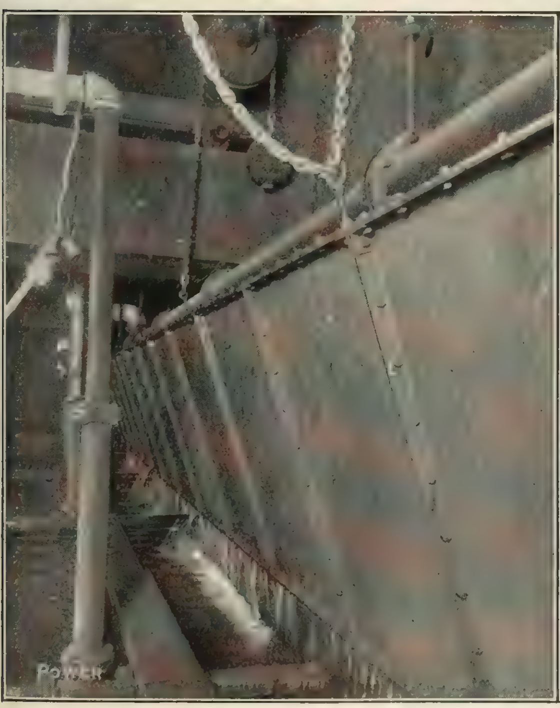

Fig. 20. Damper and Flush Pipes

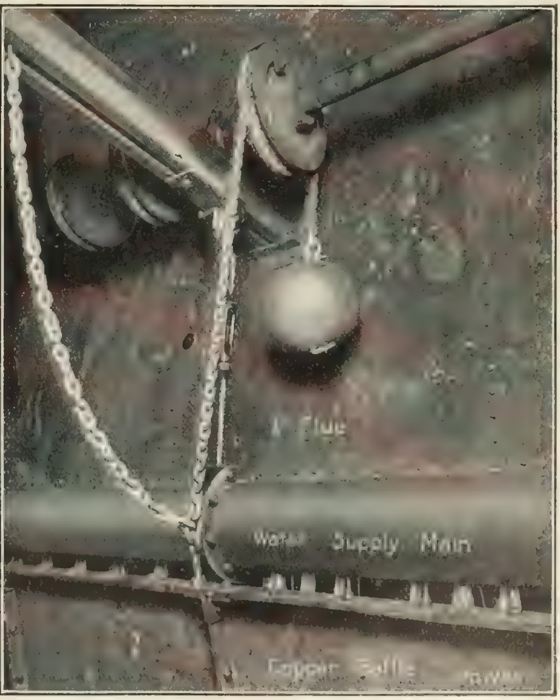

Fig. 21. Showing Weights and Water Main

These acids have given much trouble, as they are so corrosive that it was exceedingly perplexing to find a material for the baffle that would resist the action of the acids. A sheet-iron baffle was eaten away in two weeks. Then enameled sheet iron, made in furnaces especially constructed to suit the size of the sheets, was used; these sheets failed quickly, as the enamel cracked off when subjected to the heat of the flue and the expansion of the metal.

Asbestos board was next tried; it resisted the acids, but became soft on the surface because of the water, and it soon deteriorated. Experiment was made with a baffle of wire glass, but it broke almost as soon as installed. Glass would be an excellent material, as it will withstand the moisture and acids, but when a hard or flint glass is employed it will not withstand the internal strains to which a baffle is subjected. If made of a highly alkaline glass, and therefore very soft, the heat of the gases so softens the baffle that it warps.

A material very high in silicon was tried, but it too was so brittle that it cracked after a few hours' service. Up to the present, dampers made of No. 8 gage copper, flanged and fastened with 3/8-in. copper bolts, the ends being reinforced with 2½-in. copper bar, have given the best results. The inside face of the baffle over which the water runs shows no deterioration after several weeks' service, but the outer surface has been attacked slightly. Numerous acid-proof and heat-resisting paints have also proved failures.

FLUES PAINTED AND LEAD LINED

The flues at Waterside are of 3/8-in. steel plate, reinforced with angle irons, and are painted inside and out with linseed oil and red lead. The lead lining, placed in the bottom of the flue forming the water tank, is about 1/8 in. thick, and is laid on a concrete mattress about 1½ in. thick, as shown at *K*, Fig. 18. A copper apron or flashing *L* is all that is needed to protect the lead lining that extends above the surface of the water.

Tests have shown that this cinder catcher has an efficiency of about 95 per cent., which is equivalent to reducing the solid content of the gases to 0.02 grain per cu.ft., which compares favorably with the scrubbers and washers used for cleaning blast-furnace gas

Fig. 20 shows the damper and the supply lines to the flush pipes in the bottom of the flue. These flush pipes are of 4 in. diameter each, spaced 8 ft. apart, of cast iron, and have holes in the bottom spaced at 4-in centers and pointing at an angle of 60 deg. toward the bottom of the flues, so as to drive the cinder, when flushing, to a hopper at one end of the flue, as in Fig. 18. Fig. 21 is a view of the top of the damper and the water trough.

Cinder catchers constructed on the principle of the one just described are applicable to blast furnaces, cement mills, various metallurgical furnaces, and, according to the inventors, to locomotives, the sparks from which are often so damaging to property.

ARRESTERS IN OTHER LARGE PLANTS

The boilers in the Gold St. station of the Brooklyn Edison Illuminating Co., and those in the 201st St. station of the United Electric Light and Power Co., have cinder arresters of the same general design as the one described in this issue. All arresters were made by the Metropolitan Engineering Co., Atlantic Ave., Brooklyn, N. Y.

⁂ ⁂

Notes on Boiler Attachments*

SYNOPSIS—Some practical points relating to safety in the operation of steam boilers.

⁂

THE SAFETY VALVE

There is no more certain way of blowing up a boiler than by blocking the safety valve. The popular idea that a boiler will explode with great damage by allowing the water to get low and pumping in cold water is not altogether correct. There might be an explosion but certainly not one of any magnitude. When much property damage is reported it can be safely concluded that there must have been considerable water in the boiler at the time of the explosion.

At 100 lb. steam pressure, the water in a boiler is at a temperature of 338 deg. F., and if a rupture occurs, its temperature immediately falls to 212 deg., this loss of heat being taken up by the water so that about 13 per cent. of the weight breaks into steam. A horizontal return-tubular boiler, 72 in. by 18 ft., contains about 20,000 lb. of water at the normal water level. Imagine the effect of 2600 lb. of this water breaking into steam instantaneously. Before it comes to equilibrium with the atmosphere it must expand to 1600 times its volume, while dry steam at 100 lb. gage pressure would expand only seven times its volume. These are only approximate figures, intended to emphasize the great amount of energy stored in the water and the importance of guarding against any condition that may set this energy free.

It is surprising to learn of the number of cases where a stop valve is placed between the boiler and its safety valve. Then there is the fellow who hangs an extra weight on his safety-valve lever to stop it simmering. The engineer in charge of the large, well equipped plant, who would be insulted to find himself classed with the other two, frequently removes the try lever from his pop valve and allows some of these valves to become "frozen" by rust and corrosion from nonuse. He is not very far removed from the man who put the stop valve between the boiler and the safety valve.

With lever safety valves many instances are known where the stem has become "frozen" to the bonnet. Proper care is not always exercised to see that the lever is at right angles to the stem and that there is a proper knife-edge contact between the stem and lever. A flat top to the stem makes a material difference in the distance from the fulcrum, and such a valve may start simmering rather low and not blow strong until the pressure is considerably in excess of the supposed load.

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*Abstract of paper by R. T. Burwell, read before the Practical Refrigerating Engineers' Association, Dallas, Texas.

WATER GAGES AND COCKS

The best practice requires that each boiler shall have a glass-gage and three gage-cocks. Where water columns are used, they should be of ample size and be connected to the boiler by liberal-sized connections, the usual standard being 1¼-in. pipe. These connections should be as direct as possible, and wherever elbows are necessary it is best to have tees or crosses with plugs to permit a thorough cleaning of the pipes. The drain or blowoff to the water column, frequently too small to properly flush and test the column, should be of 1- or 1¼-in. pipe and led to the ashpit or out of doors. Such a pipe ending in the boiler room is not only a menace to those in the plant, but it is an indication of carelessness.

One of the most frequent criticisms an inspector has to make is that the gage-cocks are out of order, either stuck or without handles for operating. The man in charge invariably takes offense and thinks the inspector is unreasonable and impractical, since the glass water gage is depended on to show the water level, but suppose the glass breaks and another cannot be put in promptly. It is generally too late then to get them in operating condition. Besides, the management loses sight of the important fact that defective gage-cocks are sometimes troublesome and costly witnesses in case of a boiler explosion.

THE STEAM GAGE

Whenever a boiler is cut into a header already under steam from other boilers, it is extremely important that this boiler be at the same pressure as the header, and this can only be insured by providing each boiler with a pressure gage. The gage should be so connected that its spring will be properly insulated from a hot flue or stack; otherwise it is apt to read incorrectly and its spring may become impaired. In selecting a steam gage, choose one having a back-lash spring, as the gage without this invariably reads incorrectly by a few pounds, due to the back lash in its gearing.

STEAM PIPING AND FITTINGS

Due thought should be given to the pressure carried and the pipe and fittings selected accordingly. The design should be simple, with a proper allowance for expansion, and it is preferable to make connections from boilers as uniform as possible. All screwed joints should be made with great care as so many serious accidents have resulted from the failure to enter the pipe sufficiently into the fitting. One of the most important points in connection with steam piping is to see that all pockets are provided with drains; better still, arrange the piping so as to avoid pockets as far as possible. The stop valve, for instance, should be in the horizontal portion of the pipe connecting the boiler to the header.

THE BLOWOFF PIPE

That the blowoff pipe is the most generally neglected attachment about the boiler accounts for the many accidents resulting from the failure of such pipes. In the case of the horizontal tubular or flue boiler, the blowoff should be located on the bottom of the shell, as near the rear head as possible to prevent any accumulation or deposit back of the opening. A suitable pad should be provided, as the thickness of the shell alone does not provide sufficient depth of thread, and the greatest care should be exercised in selecting the pipe and fittings to see that all joints are properly made up. Even for low pressures, a blowoff valve of heavy design should be selected and special attention given to the strength of the bonnet.

Where cocks are used, the ordinary plug is to be discouraged since there is too much chance of the plug jumping out in case the attendant knocks it up in his effort to open the cock. A cock held down by a bonnet is preferable, and it should always be remembered that a cock or quick-opening valve should be operated slowly; otherwise serious results may ensue from water-hammer.

The size of pipe is also a material factor in the effects of water-hammer, and for that reason 2½-in. pipe is generally adopted as the safe limit. The blowoff pipe should be protected from the direct action of the fire, and whenever the feed water leaves any deposit, the blowoff valve should be opened at frequent intervals.

It is surprising how clean a boiler can be kept by using a little solvent whenever necessary and opening the blowoff valve about every two or three hours. In doing this better results are obtained if the boiler is not pumped up, since this disturbs the deposit. By frequent blowing it is necessary to blow out only a little water at a time. This applies to feed water in which the solids in solution are precipitated by heat without materially increasing the density of the water. Where a large portion of the solids remain in solution until the density is increased to a certain point, such as in sea water, it is necessary to pump up and blow down.

In most cases the blowoff valve is in a dark, narrow passage between the rear of the setting and the building wall, where there is practically no chance for the attendant to escape in case of the failure of this pipe or its fittings. Where the building wall is close enough, an opening should be made opposite the valve so that the attendant can stand outside of the building while operating it and, if this is not possible, an extension handle could be attached to the valve so that it can be operated from the side of the setting. When the frequency of accidents is considered and that they generally result in serious personal injury or death, the importance of adopting every safeguard to protect those in charge of the boiler can be realized. The failure of a blowoff pipe inside the setting is a serious menace to the fireman in front of the boiler, and this might be lessened by arranging the rear cleaning door so that it will offer the least resistance to the steam and water, and by the adoption of firedoors that will act as a check.

FEED PIPE

The blowoff cannot perform its proper function if the boiler is fed through it. Feeding through the blowoff not only disturbs the deposit and prevents it from being properly removed, but as the pipe is at a much lower temperature than the fire sheets, it produces strains in the material which sooner or later will become manifest in leaky seams and cracked plates. In addition, it generally results in the regulating valve being inconveniently located for the fireman, and if the blowoff pipe fails it is impossible to keep the pump on the boiler until it is sufficiently cooled down. Feeding below the tubes in fire-tube boilers is also open to the objection that it produces excessive strains in the shell plates. The better plan is to let the feed discharge just below the water level. Care should be taken to keep the discharge end of the feed pipe clear, as it has a tendency to become obstructed where there is any scale forming matter in the water. Place the feed main and the regulating valves at the front of the boiler in easy and convenient control of the fireman.

FUSIBLE PLUGS

These plugs are not always reliable and in certain types of boiler it is doubtful whether they do any good; but their failure to work is frequently due to improper installation or to allowing the filling to become decomposed or covered with deposit from long neglect. If a fusible plug gives a correct alarm once in a hundred times it has done a great service and its presence is apt to prove a friendly witness after an explosion.

In addition to the ordinary fusible plug there is one which melts under the action of steam at about 240 deg. It is placed on the end of a pipe about 2 ft. above the top of the boiler and the pipe extends into the shell to the low water line. As soon as the water falls to the bottom of the pipe, steam enters, melts the plug and blows a whistle. A valve which can be locked open to prevent tampering makes it possible to shut off the pipe and insert a new plug without closing down the boiler. Highly satisfactory results have been obtained from this device and it is especially valuable for water-tube boilers in which the ordinary plug must be placed at points where the gases are not always of sufficient temperature to melt it and it is therefore an uncertain protection.

* * *

Power-Plant Accounts--I

One keeps an account because he wants to know something. The account must, therefore, be kept so that it will tell him what he wants to know. The items which go into it and the method of keeping it will depend altogether upon what use is to be made of it; upon what it is supposed to show, and the first thing to do is to get this *purpose* of the account clearly in mind.

If the purpose of the account is simply to show the proprietor or manager of a business what it costs to run his power department, the account will consist of the summation of the items chargeable to that account. These items may be divided into two groups:

Maintenance	Attendance
	Fuel
	Water
	Repairs
	Boiler compound
	Oil
	Waste
	Packing
	Tools
	Misc.
Fixed Charges	Interest
	Depreciation
	Taxes
	Insurance

Those of the first group ought to be available from the running accounts of the concern.

ATTENDANCE

The books ought to show how much has been paid in wages to power-plant attendants. When the time of a man is divided between the power plant and other departments, as a master mechanic who has charge of all the machinery of a mill and really devotes some time and energy to the power plant, or a laborer who wheels ashes and does laborer's work around the power plant a part of the time, their salaries or wages should be charged to the power plant in proportion, as nearly as may be, to the time which is spent upon the power-plant work to the exclusion of their activities in other directions.

It is always a question where to stop in this direction. Some accountants want to charge to the power plant a proportion of the president's salary, of the expenses of the bookkeeping department and of the stipend of the office boy. There it is still a question of what is the purpose of the account. The president of a manufacturing concern of which the power account is a small factor, who knows that his salary is no more because he has a power plant and would be no less if he bought his power ready made, will probably not charge the power account with any of his salary. In an electric company, where the power is the whole product, the administration has a different relation to the power account, and salaries of officers not directly occupied with the plant would go into the costs of the administration of the whole business. The item "attendance" in the first group is intended to cover the money paid for labor and attendance, as of engineers, firemen, coal and ash handlers, boiler cleaners, etc.

FUEL

The books of the company ought to show the amount paid for fuel. So far it is a question of the money paid for fuel, not how much fuel has been gotten for it. The books may not, however, show how much was paid for fuel for the power plant as distinct from fuel for other purposes, as heating and manufacturing processes. Obviously, unless there is some way of determining this principal item there can be no account kept which will amount to anything. When fuel is used for both power and heating, as where the same boilers furnish the steam for both, or where the heating is done with exhaust steam, the question of charges and credits to each of these departments becomes very much involved, and it may be practically impossible to differentiate them entirely, but it is usually possible to keep an account so as to get a satisfactory answer to some particular question, if that question is definitely stated. Whether one credits his power plant with what the heating would have cost if it had been done otherwise, or charges his heating with only extra fuel burned in the power plant by reason of the demand for steam (live or exhaust) used for heating, will depend upon whether he wants to know how valuable his plant is to him in its combined capacity as a source of power and heat, or how much his power would have cost him if there had been no heating to do.

WATER

With the water, as with the fuel, it may be difficult to apportion to the power plant its share. Even when the water supply comes from the city or a water company, and the books show the amount of the water bills, it is impossible to tell how much of this should be charged to the power plant unless separate meters are used. Reliable meters are now available at moderate prices. If the advantage of knowing what one is doing, how he is doing it, and why he is not doing better is worth the cost of such appliances, they should be provided. If they are not, there is no use of talking about accounts. When the water is available, as from a pond or river, it is not necessary to make a separate charge for it, as the items which go to make up the cost of handling it will come in with the other charges. When a water-treating plant is used, the power plant should bear its proportion of the expense of running it.

OIL, WASTE, ETC.

Here, again, there must be some way to charge to the power plant only that which it uses. In a factory or machine shop the books will show the cost of oil and waste for the whole concern, but some system must be followed whereby it may be known how much of it goes into the engine room.

INTEREST

If a man has to borrow the money to buy his steam plant he will have to pay interest upon it.

If he has the money and does not put it into the steam plant, he can lend it and get interest upon it, which he sacrifices if he spends it for a power plant.

In any case, therefore, the interest upon its cost should be included as one of the standing charges against a plant, remembering, however, that any profit which the plant shows over other means of getting the power is over and above the profit which could have been had by investing the money otherwise at the assumed rate.

DEPRECIATION

Suppose an engine costs $4000 and will last 20 years. Then every year the plant uses up not only so much coal and water and oil, but $200 worth of engine. This is true of all of the components of the plant, including the chimney and the power house. Some of them will be used up faster than others. It is usual to charge off about 5 per cent. per year of the total cost of the plant to this account.

If one set aside each year 5 per cent. of the cost of his plant he would, at the end of 20 years, have back the capital which he had invested, and be able to replace the plant, which it is assumed would have worn out in that time. In other words, he is collecting back from the plant in installments the money which he borrowed or appropriated with which to buy it.

Should the plant continue to pay interest on that part which it has already paid?

If interest were really being paid, as upon notes or bonds, the yearly collection for depreciation could be applied to paying that amount of the notes or to refixing that amount of the bonds, so that the interest for the second year would be upon the original investment *less* he depreciation charged off the first year, the investment nd interest charge being decreased each year until the debt was paid and the interest ceased. The same reasoning should apply to the general case.

If the object really were to have enough on hand to eplace the plant at the end of its assumed life, and the money were really set aside each year as it is charged to the power account, and invested at the rate of interest which it was assumed that one could get when the interst account was established, it would be found that, on ccount of the compound interest, the total amount would ave accumulated long before the time was up. It would take an annuity of less than 3 per cent. to redeem an investment in 20 years at 6 per cent. This sinking-fund phase of depreciation is to be considered in accounts kept for some purposes. The method of treatment will depend upon what the man who keeps the account wants it to tell. It will not make any difference in the amount of money which he spends on his plant, but it may affect the apparent cost of running it.

Upon what is depreciation to be charged? One would charge it upon an exciter unit or a steam pump, but not upon a monkey wrench.

The distinction is this. If the money paid for it is not charged directly to the power account, it may be charged to the investment account and its cost collected within its term of usefulness by charging depreciation upon it. If it is not so treated it should be charged in its entirety as miscellaneous supplies. A belt, for instance, would be charged all at once, and while it would make the power cost high for that month or year, it would average up in the long run. When the capital invested has been all collected through depreciation, this item should be taken out of the depreciation account and the collection of depreciation upon it stopped.

TAXES AND INSURANCE

These items should be available from the bookkeeper. It will still be a question of apportionment, but as both of these items are based more or less directly upon value, they may be taken as a percentage of the cost of the plant. The charge should really be the amount which is paid for taxes and insurance over and above what would be paid if the power plant were not there.

The Waste of Not Using the Water Powers*

Water power is unlike most other natural resources in that it is not diminished by use, nor is it conserved by nonuse. Coal which is not used today remains to be used hereafter, but the energy of water which is allowed to flow by unused neither increases nor diminishes the future supply, but it is irretrievably lost. Our supply of coal—the principal source of energy—while vast, is not unlimited. The utilization of water power results in the saving of coal for future use. In other words, the real waste of water power is its nonuse, while its development effects a conservation, not only of water power but of our fuel supply as well.

The importance of effectively utilizing the water powers of the country is, therefore, obvious. The power now (February, 1912,) required to operate the industrial enterprises and public-service utilities of the country (excluding steam railroads and vessels) can be safely estimated at not less than 30,000,000 hp. Approximately 6,000,000 hp. is now generated by water; the rest is generated from fuel, mainly coal. The quantity of coal required to produce a horsepower-hour in steam varies according to the quality of the coal and the size and efficiency of the engines. It is claimed that under the most favorable conditions a pound of coal can be made to produce one horsepower-hour. From this minimum the estimated quantity ranges as high as even 6 or 7 lb. Assuming, however, that on the average a horsepower-hour in steam can be produced by 3 lb. of coal (and this quantity probably understates the average quantity of coal required and the corresponding saving by the substitution of water power), the power now produced by water saves at least 33,000,000 tons of coal per year. This is based on a 12-hr. day.

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*"Water Power Development in the United States," by Herbert Knox Smith.

By reason of distance from markets, cost of development and other causes, it will doubtless be many years before a quantity equal to even the "minimum potential" water power of the country, 32,083,000 hp., can be advantageously developed. It is certain, however, that under favorable conditions several additional millions of horsepower can now profitably be developed from water, thus effecting a still further conservation of our fuel. The millions of water power economically available, but undeveloped, represent absolute waste.

* *

Calculating Power in Alternating-Current Circuits--II

By Norman G. Meade

SYNOPSIS—Explanation of the terms inductance, reactance and impedance, and their effect in calculating alternating-current circuits.

*

When making calculations for alternating-current circuits, in addition to resistance one must consider three other factors, inductance, reactance and impedance. Inductance is the coefficient of self-induction and equals the product of the total number of lines of force N threading a coil, when the current is one ampere, and the number of turns T, in the coil, divided by 10^8, or 100,000,000. This coefficient is usually denoted by the letter L, which is the practical unit of self-induction expressed in henrys.

$$L = \frac{N \times T}{10^8} \text{ henrys}$$

If it is known that the number of lines set up increases directly with the current, the above formula may be changed to read:

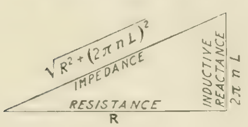


FIG. 8

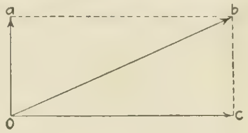


FIG. 9

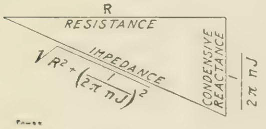


FIG. 10

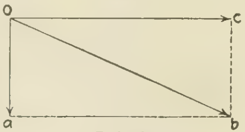


FIG. 11

Figs. 8 and 9 Represent Graphically the Relation between Resistance, Inductive Reactance and Impedance. Figs. 10 and 11 Represent Relation between Resistance, Condensive Reactance and Impedance.

$$L = \frac{\textit{magnetic flux} \times \textit{turns}}{\textit{current} \times 10^8} \text{ henrys}$$

For illustration, assume an electromagnet of large proportions to have the following data:

Total magnetic flux =	30,000 lines
Number of turns of wire =	1,000
Amperes =	1
10^8 =	100,000,000

Substituting in the formula

$$L = \frac{30{,}000 \times 1000}{1 \times 100{,}000{,}000} = 0.3 \text{ henry}$$

Inductive reactance resulting from the counter electromotive force of self-induction equals 2 π times the frequency times the inductance in henrys or $2\pi n L$ in which,

$\pi = 3.1416$;
n = Frequency;
L = Henrys.

Like resistance, inductive reactance is measured in ohms.

Considering the same problem as before, assume the electromagnet to be connected to an alternating-current supply having a frequency of 25 cycles. Then the inductive reactance would be

$$2 \times 3.1416 \times 25 \times 0.3 = 47.12 \textit{ ohms}$$

or roughly 47 ohms.

The self-induced or counter-electromotive force is greatest when the rate of change of the current strength is greatest; this occurs when the current is passing from a positive to a negative value; that is, through zero. Hence, the maximum values of the counter-electromotive force and that part of the impressed electromotive force required to overcome straight resistance are displaced 90 electrical degrees.

This is shown graphically by Fig. 9 in which *oc* represents the component of the impressed electromotive force required to overcome resistance and *oa* that necessary to overcome reactance. The resultant is *ob*. This combined effect of reactance and resistance is called impedance or the "apparent" resistance of the circuit—i.e., the quantity which when multiplied by the current will give the total impressed electromotive force.

Bearing in mind the relation in Fig. 9, the value of the impedance may be found by treating the problem as a parallelogram of forces and solving the right triangle, Fig. 8. The base represents the resistance, the altitude inductive reactance and the hypotenuse the impedance. Employing the theorem that the hypotenuse of a right triangle equals the sum of the squares of the two sides,

$$\textit{impedance} = \sqrt{R^2 + (2\pi n L)^2}$$

Let,

I = Current in amperes;
R = Resistance in ohms;
E = Electromotive force in volts;
Z = Impedance.

Then the following relations hold true between Ohm's law for circuits containing resistance only, and the derived formulas for alternating-current circuits containing impedance.

RESISTANCE ONLY	WITH IMPEDANCE
$I = \frac{E}{R}$;	$I = \frac{E}{Z}$;
$R = \frac{E}{I}$;	$Z = \frac{E}{I}$;
$E = I \times R$;	$E = I \times Z$.

Now, assuming the electromagnet to have an ohmic resistance of 150 ohms, the impedance of the magnet equals

$$\sqrt{150^2 + 47^2} = \sqrt{22{,}500 + 2209} = \sqrt{24{,}709}$$
$$= 157 \textit{ ohms} = Z$$

If the electromagnet requires a current of 10 amp. for its operation, the impressed electromotive force necessary to cause such a value of current to flow through the coil is

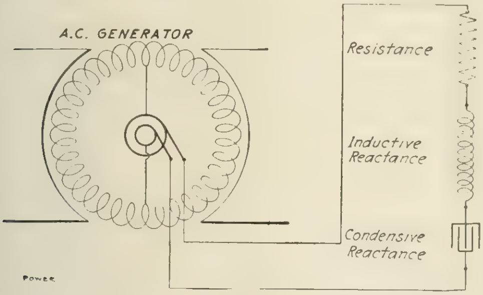


Fig. 12. Illustrating Circuit Containing Resistance, Inductive Reactance and Condensive Reactance

$$E = I \times Z = 10 \times 157 = 1570 \textit{ volts}$$

In the foregoing problems the current is lagging behind the electromotive force.

PROBLEM—An alternator with a rated electromotive force of 1000 volts at a frequency of 60 cycles per second supplies current to a system of which the resistance is 100 ohms and the inductance 0.3 henry. Find the value of the current, angle of lag, power factor, apparent watts and true watts.

$$I = \frac{E}{\sqrt{R^2 + (2 \pi n L)^2}}$$

$$= \frac{1000}{\sqrt{100^2 + (2 \times 3.1416 \times 60 \times 0.3)^2}}$$

$$= \frac{1000}{150.8} = 6.63 \textit{ amp.}$$

$$\textit{reactance} = 2 \pi n L = 113.04 \textit{ ohms}$$

$$\textit{tangent of angle} = \frac{2 \pi n L}{R} = \frac{113.04}{100} = 1.13$$

From a table of trigonometrical functions it is found that the angle corresponding to a tangent of 1.13 = 48 deg. 30 min. Power factor = the cosine of the angle = cosine of 48 deg. 30 min. = 0.662.

$$\textit{apparent watts} = E \times I = 1000 \times 6.63 = 6630$$
$$\textit{real watts} = E \times I \times \textit{power factor} = 1000 \times 6.63$$
$$\times 0.662 = 4389 \textit{ watts}$$

Condensive reactance, or capacity, is expressed by $\frac{1}{2 \pi n J}$ in which n is the same as before and J is in farads. The expression is analogous to that for reactance, $2 \pi n L$ in circuits where self-induction is present. The impedance in a circuit containing both resistance and capacity is, therefore, $\sqrt{R^2 + \left(\frac{1}{2 \pi n J}\right)^2}$. This is illustrated graphically by Figs. 10 and 11, where the conditions are the reverse of those shown by Figs. 8 and 9.

Let resistance = 100 ohms;
J = 50 micro-farads = 0.00005 farad;
n = 25.

The impedance =

$$\sqrt{100^2 + \left(\frac{1}{2 \times 3.1416 \times 25 \times 0.00005}\right)^2}$$
$$= \sqrt{100^2 + 127^2} = \sqrt{10{,}000 + 16{,}129} = \sqrt{26{,}129}$$
$$= Z = 161 \textit{ ohms}$$

Circuits frequently contain resistance, inductive reactance and condensive reactance (capacity). This can be illustrated by incandescent lamps, induction motors and lead-covered cables, as shown graphically in Fig. 12. To illustrate the fact that condensive reactance, causing a leading current, may more than correct a lagging current due to inductive reactance, refer to Fig. 13, in which oa represents condensive reactance and oa' inductive reactance; oc = resistance and the resultant diagonal ob = impedance. Fig. 14 shows the components arranged in the form of a right triangle. Let

$$2 \pi n L = 50 \textit{ ohms}$$
$$\frac{1}{2 \pi n J} = 150 \textit{ ohms}$$
$$R = 200 \textit{ ohms}$$

Then

$$Z = \sqrt{R^2 + \left(2 \pi n L - \frac{1}{2 \pi n J}\right)^2} = \sqrt{200^2 + (-100)^2}$$
$$= \sqrt{40{,}000 + 10{,}000} = \sqrt{50{,}000} = 223 \textit{ ohms}$$

There will now be a leading current. Synchronous motors with an overexcited field possess the same characteristics in effect as condensers and are used to correct the power factor of lines connected to induction motors, as will be explained in a later article. In the last problem, if the inductive reactance and condensive reactance had had the same value, one would have counteracted the other and unity power factor would have resulted.

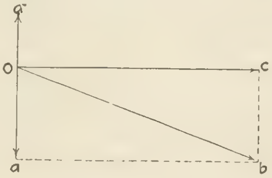
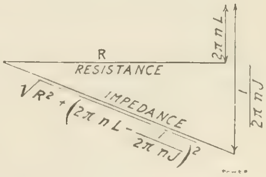


FIG. 13



14

Graphic Representation of Resistance, [illegible] and Condensive Reactance in the Same [illegible]

Remodeling a Small Belt-Driven Steam Plant

By Henry D. Jackson

SYNOPSIS—A change to central-station current did not pay. The difference between power costs as figured by a central-station solicitor and a consulting engineer.

⁂

When a manufacturer asks a maker of power-plant apparatus to advise him as to the best machine to install in his plant, he realizes, however great his confidence in the dealer, that such advice may not be entirely disinterested. This being the case, why should a manufacturer rely upon information given by a central-station solicitor as to the cost of power in his plant when considering any changes to improve the operating economy?

He is likely to get advice which is frankly and entirely in favor of the central station. The solicitor is engaged to influence plant owners to install central-station power, and naturally uses every means at his disposal to install this power.

To one plant a central-station solicitor submitted the following figures as to the cost of power under present conditions:

Insurance, taxes and interest	$200
Depreciation	200
Maintenance and repairs	175
Coal	2450
Water	170
Oil	100
Removal of ashes	65
Labor	1035
	$4395

He found that the total power required to operate the plant was approximately 75.6 hp. The plant supplied a number of separate manufacturing establishments, each paying so much for floor space, including power. It was comparatively old and operated entirely by belts, and as each of the floors was controlled by the tenants, the shafting was neglected, so that the friction loss was excessive. The conditions were such that the power plant was very nearly to the limit of its capacity.

The cost of motors required for the electrification of this plant was $2254, and the wiring was $600, these figures being given by the solicitor. He also gave the following estimate of the cost of power under these conditions:

Coal for heating	$450
Removal of ashes, etc.	25
Labor—fireman, etc.	520
Maintenance and repairs	50
Interest, taxes and insurance	125
Depreciation	110
Power	2575
	$3855

These figures show a saving of approximately $540. He also said that it would be better to sell the power to each of the tenants by meters, which could be charged to them at a rate of 4½c. per kw.-hr., thus making an additional profit to the owner of $1250 and a total net gain by electrification of $1790.

These figures were so attractive that the owner accepted them, installed motor drives, dismantled his plant to a great extent, and purchased power from the central station.

After operating the plant for something over a year he was disagreeably surprised to find that the amount of coal burned for heating was considerably in excess of that estimated by the solicitor. He was also surprised to find that the labor cost was considerably in excess of the estimate. This labor was not for firing or for general work about the plant, but was for work in connection with the motors. He was constantly calling in either a man from the central station or from the local electrical contractor to install brushes on his motors, clean up commutators, and to oil and generally oversee the motors. So that his total labor expense on this item amounted to approximately $600 per year, in addition to the supplies which he had to buy. He also found that the oil required for keeping the motor bearings in good operating condition, as well as the waste and other material necessary for cleaning them, amounted to between $60 and $75 a year. These items reduced the gain to less than $1000, and this was largely paper profit.

A consulting engineer to whom the matter was submitted for an unbiased report, gave figures which were decidedly at variance with those of the central-station agent. He called the attention of the manufacturer to the fact that the fixed charges on his original plant as given in the report were at the rate of 24 per cent. per year, whereas the fixed charges on the plant as electrified were taken at a rate of about 10 per cent. It was also found that the fixed charges under the condition of electrification were taken only upon the new equipment, no attention whatever being paid to that portion of the old plant which was still in service, nor was the interest taken into account on that portion of the machinery which had been dismantled and held for sale.

This is an item which is frequently lost sight of when considering making changes in a plant. If, for instance, a plant has a certain value, and for certain reasons it becomes necessary to displace it, the difference between the value it has in place and the value at which it is sold must be taken care of in the new plant, as it is still subject to interest, unless this machinery has been subject to such depreciation charges that it represents merely its sale value at the time it is discarded.

In the case under consideration the engines, boilers, etc., were subject to interest, maintenance, depreciation, etc., and surely if such was the case they were in pretty fair condition, and as the engine and part of the shafting were for sale, the interest charges on these must certainly go on at full value until they are sold, and thereafter at that value minus the price at which they were sold.

In this instance the original plant value had been assumed at $2400; the engine, etc., held for sale at $400; and the cost of the electrical equipment was $2854. Therefore, the total plant subject to interest was $4854, and subject to depreciation, maintenance, insurance and taxes, $3854. Tabulating these gives:

Interest at 6 per cent. on $4854	$291.24
Depreciation at 5 per cent. on $3854	192.70
Maintenance at five per cent. on $3854	192.70
Taxes and insurance at 2½ per cent. on $3854	96.35
	$772.99

As a matter of comparison of interest to the plant owner he was shown that if the fixed charges on this machinery were taken at the same rate as on the old plant it would give $1006.32.

For operation, the engineer gave estimates as follows:

Coal for heating	$600
Labor	1120
Oil, etc.	60
Water	50
Removal of ashes	15
Cost of power	2575
	$4420

This, taken in connection with the engineer's fixed charges, made a total cost of $5193, or $5426 when taken in connection with the fixed charges at the rate charged by the solicitor on the original plant. As the plant originally operated at a total cost of $4395, the installation of electric motors and the purchase of power increased, rather than decreased, the cost.

The engineer suggested that so long as the electric equipment was installed it might be worth while to install a generator utilizing the old engine to drive it, and also to install a small direct-connected unit for lighting purposes. He submitted the following figures:

Cost of equipment of old plant	$2400
Electric motors and wiring	2854
New generators and switchboard	2070
Total	$7324

Interest at 6 per cent., maintenance and depreciation each at 5 per cent., taxes and insurance at 2½ per cent., would make the total fixed charges $1355.

The average load on the plant was approximately 40 hp., making due allowance for efficiency of generator and transmission between it and the engine.

With the engine put in good working condition the coal would amount to approximately 5 lb. per hp.-hr. The total operating cost for power and heat would then be:

Coal	$1289
Labor at $18 a week	936
Water	100
Oil, waste, etc.	100
Ash removal	50
	$3830

This total also covers the interest, maintenance and depreciation on the lighting unit.

The coal cost for lighting on the basis of 24,000 kw.-hr. for the year would amount to about $270, making a total operating cost of $4100, showing a saving over the original operation by belting and supplying light in addition.

The engineer further intimated that it had been decidedly unwise to take out the old shafting and rearrange the plant, as it probably would have been possible, by thoroughly revamping the plant, to have made a reduction in the original coal bill of about $1300, this being secured by proper lining up of the shafting, overhauling of the belting, and generally reducing the friction loss. With this done, the lighting unit could have been installed as the boiler capacity would have been sufficient to handle it, and the installation of this unit would have allowed the owner to obtain the additional income from this source, which would have resulted in a saving approximately the same as that resulting from the installation of the electrical apparatus without having to go to the same first cost.

Listen to the solicitor but consult your engineer.

⁂ ⁂

Steam Required for Heating Industrial Plants

By Harry C. Spillman

For industrial plants sufficient radiating surface is usually installed to heat the buildings to 65 deg. F. in zero weather. The steam pressure carried on the mains varies from 3 to 10 lb., depending upon the design of the system and the amount of steam required. The following table gives the number of British thermal units per square foot of heating surface at different steam pressures:

Abs. Steam Press., Lb.	B.t.u. per Sq.Ft. per Hr. for W.I.Coils*
6	147
8	167
10	185
12	199
14	213
16	226
20	248
25	274
30	295
35	317
40	338
50	377

*For cast-iron radiators reduce the B.t.u. 10 per cent.

Tests made on a large scale have shown for each month the following percentages of total steam used during the heating season:

	Per Cent.
October	5
November	5
December	15
January	25
February	20
March	20
April	10
	100

It has been found safe to deduct 30 per cent. from the number of days in the season to allow for mild weather and figure the balance for zero requirements.

Take a concrete example of a vacuum system having 20,000 sq.ft. of wrought-iron heating coils. Steam is supplied at an average pressure of 5 lb. gage or approximately 20 lb. abs. The vacuum is about ½ in. at the coils and 10 in. at the pump. The condensed steam from the coils is returned to the boiler at 150 deg. F.

From the first table it is evident that each square foot of heating surface will transmit 248 B.t.u. per hr. The heating system will deliver

$$20{,}000 \times 248 = 4{,}960{,}000 \textit{ B.t.u. per hr.}$$

The heating season has 210 days, and deducting 30 per cent. for mild weather leaves 147 days on which heat is required. This is a safe assumption, as most of the mild days will require a small amount of heat and the majority of cold days will demand heat from every coil. Then during

$$147 \times 24 = 3528 \textit{ hr.}$$

heat will be required. The heating system consumed 4,960,000 B.t.u. per hr. and each pound of steam at 5 lb. pressure contains 1156 B.t.u. above 32 deg. The temperature of the condensation will be about 212 deg., and the heat per pound of water 180 B.t.u. Each pound of steam will therefore give up

$$1156 - 180 = 976\ B.t.u.$$

Then the heating coils will demand

$$\frac{1,960,000}{976} = 5082\ lb.$$

of steam per hour. The heating system is operating 3528 hr., so that the coils will use

$$5082 \times 3528 = 17,929,296\ lb.$$

of steam during the season. The steam mains which supply the heating coils will condense 5 per cent. of the steam, and to deliver 17,929,296 lb. of steam to the coils it will be necessary to transmit

$$\frac{17,929,296}{0.95} = 18,872,943\ lb.$$

of steam. As stated, the vacuum pump returns the water to the boiler at 150 deg., and as it is condensed in the heating coils at 212 deg., there is a loss of

$$212 - 150 = 62\ deg.$$

or 62 B.t.u. per lb. This cause a loss of

$$17,929,296 \times 62 = 1,111,616,352\ B.t.u.$$

which is equivalent to

$$\frac{1,111,616,352}{976} = 1,138,951\ lb.$$

of steam. The total steam to heat the building will then amount to

$$18,872,943 + 1,138,951 = 20,011,894\ lb.$$

A pound of coal should evaporate 7 lb. of water, so that there should be required

$$\frac{20,011,894}{7 \times 2000} = 1429.4\ tons$$

of coal for the season. By referring to the first table it will be easy to figure out the monthly consumption.

The following results of tests made on modern reinforced-concrete buildings having about 90 per cent. of window area, show the pounds of steam required per cubic foot of volume:

	Lb. Steam
October	0.185
November	0.309
December	0.960
January	1.708
February	1.390
March	1.276
April	0.094
Total	5.922

⁂

Safety Suggestions for the Engineer

Wherever "red tape" is frequently a hindrance to the doing of things that the exigencies of the moment require, it is usually so complex as to defeat the very purpose for which it was instituted. When the object of such measures is the safety of employees, the public or of property, an occasional delay, with slight inconveniences, is better than one serious accident or real catastrophe.

Several plants, where high-tension current circuits are controlled from one central-control board, have a system of tagging the switch in a line on which work is being done. The lineman or electrician who is to work on the circuit is given a coupon from the tag tied to the switch, and the switchboard operator must not close the circuit until the electrician returns it to him, the return of the coupon being an indication that the job on the line is completed.

If the valve controlling a branch main on an automati sprinkler system should be closed, that part of the system would be useless, and serious results might follow a otherwise little blaze. In one factory all the sprinkle valves are numbered and tagged. The tags state that n one shall close any valve in the system without a signe permit to do so, except, of course, in extreme emergenc

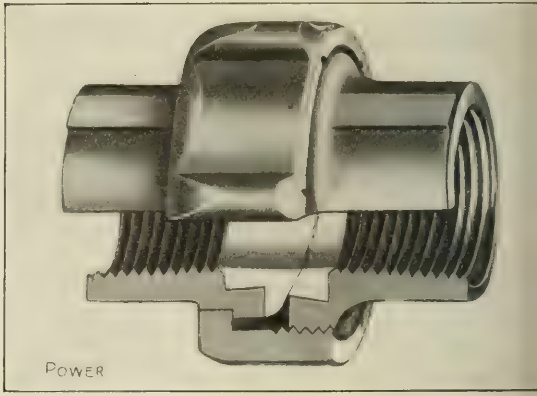
When a valve is closed a red tag is hung over a whit one already on the valve, and a coupon from the red car hung on a hook corresponding to the valve number, th hooks being screwed on a board. If a valve must be close in an emergency, the white card, bearing the date of closure and the name of the person by whom closed, is hun on the board and when the person in charge of the boar notices the white card, he immediately hangs the red car on the valve and the red coupon over the white card.

Sprinkler systems are usually in charge of the enginee and he might do well to adopt the above system in hi plant.

⁂

Rockwood Bronze-Seat Pressed-Steel Pipe Union

The Rockwood union, illustrated in section herewith is made of pressed steel with ground bronze seats s firmly clinched into place that they are practically welde to the steel halves. The bronze ball joint is densified which is an extra protection against corrosion. In addition, every union is sherardized after threading and previous to grinding, thus protecting the steel surfaces fron oxidation.



Showing Design of Pressed-Steel Union

The nut of the union is so ribbed that in places wher it might be impossible to use a wrench, any flat instrument and a hammer will be sufficient to tighten or loose the nut.

As it is often necessary to take a union apart after it ha been in service, the nut is made with slots across th face of the internal threads. By applying a few drop of kerosene, the thread surfaces may be reached by th oil, when the nut is easily loosened.

The union is made in sizes from ¼ to 2 in. Th manufacturer, the Rockwood Sprinkler Co., 38 Harlow St., Worcester, Mass., guarantees all sizes of unions to b tight and of sufficient strength, under any pressure o steam, gas or water less than 500 lb. per sq.in.

Editorials

Ability versus Appearance

Is an engineer justified in expecting an increase in salary if, in the performance of his duties, a saving in the cost of power-plant operation has resulted? Furthermore, can he expect the same treatment from his employers if he goes about his work clad in a faded-out suit of overalls and jumper?

To the first question we say "Yes," because ability should be recognized more substantially than by a pleasant "Good morning" and the same flat pay envelope each Saturday.

To the second question we say "No." Although "clothes do not make the man," they have much to do with the way he is treated by those with whom he comes in contact.

The two questions were suggested by two experiences that came to our attention.

An engineer assumed charge of a steam plant of uncertain age and condition. After familiarizing himself with the apparatus he made numerous changes which resulted in dispensing with one boiler, several pumps, five steam engines and numerous steam traps. The saving made per annum was between three and four thousand dollars in the operating expenses of a comparatively small steam plant.

An engineer effecting such a saving would be considered by most people as having made good. But his employers evidently did not think so, or if they did, they failed to show it in any substantial way. After waiting a reasonable time for an increase in salary, the engineer sent a letter to the office asking for it. This occurred weeks ago, but so far no reply has been received.

Doubtless, the engineer made a mistake in writing his request, instead of stating his case in person. Facts can be more forcibly presented verbally than in writing and arguments can be made to offset any unfavorable attitude taken by the employer.

This engineer is accustomed to dress while on duty in the regulation engineers' overalls and jumper. His appearance about the works is that of any ordinary workman, and his superiors doubtless treat him as one. He is wondering if it is because he is judged by his clothing and appearance instead of his engineering ability.

Appearance does count. Another engineer noticed that when he went to the office he was treated with but little consideration. The clerks and others acted as if they were afraid the office furnishing would be soiled from contact with his engine-room clothes. It was, "Here, you, there is that valve you want over there," or "Say, you, what is the matter with the steam heat this morning?"

This engineer decided to change this attitude of his fellow workers. He proceeded to wear a fairly good suit of clothes about the works, and a few "frills," such as a clean collar and tie. He began to assign repair work and such to his assistants and assumed the position of a chief engineer. Result: he is no longer greeted with a "Here, you," but with "Good morning, Mr. Blank." If his presence is required in the office the message is "Will Mr. Blank kindly step into the office when convenient," instead of a summons by the ringing of a bell.

Now, this engineer was just as good a man when he wore his working clothes as he is now, but his appearance belied his ability, and judgment was based on what he wore instead of what he did and could do.

This kind of snap-judgment treatment may not obtain in all cases, but it is more general than is realized. It is a natural attitude, and the fault is with the engineer. Employers like to see a clean engine and boiler room, and a neat-appearing engineer is also appreciated.

*

Stopping the Wastes

For the thoughtful there is much to ponder over in the forthcoming third annual report of Joseph A. Holmes, director of the Bureau of Mines. In the past year the bureau has done a notable work in reducing the wastes of the mineral resources now estimated to amount to not less than a million dollars a day. What it has done in one year in stopping some of the waste of natural gas alone has effected a saving of ten millions, or more than six times the total cost of the bureau's investigations to date. Had it better facilities and more funds it could accomplish more.

The present methods of producing oil are wastefu and it is necessary to show the individual operators that considerable can be saved without stopping the drilling for oil. It is the practice to waste the gas to get the oil In the Oklahoma gas and oil fields natural gas is still being wasted to the extent of some fifteen or twenty million dollars worth annually, and in all the fields of the country, over fifty million. Of this, eighty per cent. is believed to be easily preventable and the rest capable of yielding gasoline by extraction, or of being burned for useful purposes.

If the researches and investigations of the bureau, limited as they have been by lack of funds, have enabled the saving mentioned, certainly the appeal for an increased appropriation should be heeded to put added facilities at the bureau's disposal.

Besides the waste of natural gas, there is a large loss of the lighter oils produced from petroleum in pumping and handling. Also, through the flooding of oil and gas strata by underground water, heavy losses are sustained that might be reduced if the conditions could be studied and remedies applied.

Another serious fuel waste occurs in coal mining; apparently 250 million tons is lost annually in mining and handling. A thorough underground survey and examination at selected areas in each of the principal coal fields, in the belief of Director Holmes, would indicate ways to adopt less wasteful methods. This, it is estimated, could be done at the relatively trifling expense of fifty thousand dollars per annum for three or four years and probably effect the saving of a thousand dollars for each dollar expended.

With such opportunities before it for valuable service to the country, when the bureau is properly equipped, it goes without saying that the director's recommendations should not fail to receive attention. Here are definite proposals for real conservation. The country is awaking to the need of it, but Congress is much occupied with the many perplexing questions of foreign policy, tariff, rate regulations, interstate commerce, control of monopolies, water-power rights and so on *ad infinitum.* It is to be hoped, however, that in the crowd of all the other urgent and worthy subjects for consideration, Congress will not overlook this opportune time to further the deserving work of the Bureau of Mines.

No Wonder!

An explosion occurred at Arlington, Mass., causing a property loss of upward of twenty-five hundred dollars. While not a boiler of the variety most dealt with by engineers, no doubt it was a steam boiler before it became a projectile. It was a twenty-gallon copper tank fitted with a hand-regulated gas burner (which was left burning), to heat water for domestic use. The press reports have it that the cause of the explosion is "declared a mystery," and advance some fine-spun theories, but the mystery vanishes promptly, when it is known that the water-supply pipe was fitted with a check valve, which prevented the water from backing up and that there was no relief valve attached.

About as mysterious as the loss of the horse's head to the rider (sober?) who had mounted facing backward and could find only a strip of the mane—neither investigator looked in the right place.

Think of the energy stored in that tank in the form of heat and pressure ready to convert the water into steam as soon as it was released.

Another explosion occurred within a few hours in an apartment house in Brookline, Mass. Fourteen are reported injured and there is a property loss of thirty thousand dollars. The reports are so similar that they appear to have had the same "mysterious" cause. In this case "the copper tank was actually turned inside out" and "probably accumulated a pressure of two hundred and fifty pounds."

Sounds like a check valve in the supply pipe, and no relief valve again. The mystery is why men connect up tanks or boilers in such a way.

Wireless Transmission of Electrical Energy

Although electrical energy has become so commonplace that its use is regarded as an incident, it is within the memory of the most of us when its simplest applications were all curiosities. The engineer of the electric-lighting plant, modern thirty years ago, if he entered the power plant of today, would find it difficult to understand the use and operation of the numerous electrical devices found therein.

The strides that have been made in this branch of engineering have surpassed the wildest dreams of thirty years ago. On one occasion a professor of electricity, solemnly stated to his class that the trolley car would always require a trolley wire as a means of electrical transmission. Today street cars are successfully operated by means of storage batteries. The professor spoke according to the light of his time and could not see the developments destined for the future.

One of the greatest overhead charges against the electric lighting plant is the cost and maintenance of the transmission lines. Although, doubtless much thought has been devoted to the question of transmission-line elimination the problem has remained unsolved. Possibly the invention of wireless telegraphy has given inventors the key which will enable them to perfect a method of wireless electrical transmission.

The advance along this line is promising, for, according to reports, apparatus has been devised whereby electric lamps have been lighted at a distance from the generating apparatus without the aid of transmission lines.

What the success of this invention will mean is impossible to predict. With the first step taken in wireless transmission of electrical energy, it would seem plausible to predict that not only will our buildings be lighted by wireless electrical energy, but that they will be heated as well. In the same manner, commercial electrical energy could be transmitted for motor service.

It may be early to forecast what the forthcoming results of this new invention will be, but who would care to dispute that energy will soon be transmitted from the point to point without the aid of transmission lines?

*

Questions, accompanied by insufficient data, are frequently submitted to us by correspondents. While it is appreciated that, out of consideration for our time and patience, correspondents may hesitate to explain some facts and conditions for fear they are irrelevant, it is better to do so than to leave us to conjecture as to details which prove necessary to the solution of their problems. We are always glad to overlook such misconception of essentials, but it will contribute more to the purpose to have surplus data than to omit reference to a single detail of conditions that may be pertinent to the inquiry. We wish to make our answers to inquiries sent by correspondents as valuable to them as possible and to do so, we must have complete and accurate statements of the conditions affecting the questions.

*

It is incumbent on engineers to become versatile, cultivated men. If we cheapen ourselves by avoiding or slurring those subjects which educate us as men, because we cannot see that they aid us as bread-winners, our profession is but little more than a trade. We will receive lower money returns than lawyers and surgeons, and our opportunity for high service will be lessened.—*Shenehon.*

*

When we receive a contribution accompanied by a request such as this, "Kindly do not print my name in connection with this article as the ———————— Co. does not approve of its employees writing for magazines," we get a pretty strong sidelight on the company. While entirely willing to withhold the contributor's name, we would like to print the company's name so that it might get the reputation it deserves.

*

Mr. Demorest's opinion that an over-lean mixture will cause backfiring in the intake pipe, as expressed on page 281, seems a departure from the generally accepted theory and should form a basis for profitable discussion.

Correspondence

Emery around a Dynamo

In addition to the objections to emery around a dynamo, as stated in the Jan. 6 issue, under "Inquiries of General Interest," it is important to observe that if emery cloth is used for smoothing down a commutator or fitting brushes, loosened particles of emery are likely to lodge between the commutator segments.

As emery is a good conductor of electricity, this will cause short-circuits between the bars. For the same reason, emery cloth should not be used for truing up the brushes as particles of emery or of copper dropping from the brushes cause sparking and burning. For these reasons, as well as to guard against cutting of journals, emery or emery cloth should not be used on a dynamo for any purpose.

FRANK GARTMANN.

Milwaukee, Wis.

* * *

Inspecting a Return-Tubular Boiler

The article in the Jan. 13 issue, by James F. Hobart, seems to be lacking in many details and some of the essentials. Steam-boiler inspection is not only for detecting defects, but to make reasonably sure that a boiler can safely carry the pressure allowed, and to note its condition as to scale, oil, etc.

From the second paragraph one might infer that small vertical boilers were the only ones which did not permit of an internal inspection from the inside, whereas many small return-tubular boilers do not permit of such an inspection.

When cooling a boiler the author could have told how to adjust the furnace doors and damper so that the air may be made to circulate through and around the boiler after the doors in front of the tubes have been opened. Usually, when the boiler attendant wants a circulation of air through and around the boiler, he opens the damper and furnace doors and keeps the doors in front of the tubes closed.

Inspectors in this district usually wear a complete dustproof suit, consisting of hood, jacket and trousers, all in one garment, and not with a separate hood as stated; long-legged boots of light weight are worn in preference to shoes. One of the most important accessories in an inspector's kit is an acetylene lamp, or a candle holder and candles, to provide light during the inspection.

In stating what to look for when noting the condition of the setting, Mr. Hobart might have gone further, stating that the brickwork should be examined for loose and bulged walls, for settling of the walls and burned lower furnace walls.

Evidently an error has crept into the article where it is stated that if the front brickwork burns out or falls down, the dry sheet will burn. The paragraph concludes with the statement that this cannot happen with a full flush-front boiler. Evidently a full extension or overhang front is meant, as such a front overcomes the trouble as the dry sheet is outside of the furnace front.

Regarding leakage at the seams, it would have been well to mention that more than overheating of seams is a cause of distress; such as leaks caused by strained plates, due to poor construction and the use of the drift pin, cracks due to inferior quality of metal, or because of long service and by allowing cold air to strike the seams.

Not only will dirt or scale cause bulging and bagging, but the probable cause will be from oil getting into the boiler and mixing with the dirt and sediment and becoming deposited on the fire sheets. In inspecting a bag on a boiler it is important to ascertain how much the plate in the bag has been burned. The hammer test will tell this to the experienced inspector. Even small bulges when they are deep are usually forced back to place, and when the plate is cut out at the bag, the patch is always riveted to the inside of the boiler, where possible, so that a pocket will not be formed.

Mr. Hobart says that all longitudinal seams should be looked after to ascertain if they leak and he also tells what may be seen along each of the outside straps. Generally these joints are concealed by a covering or by brickwork that would have to be broken away before the joint could be seen; that this is seldom done unless signs of leakage give warning that the joint needs attention.

The last paragraph states that girth seams of boilers give little trouble. This should be true of all return-tubular boiler seams, but we find the seam that gives the most trouble to be the front girth seam over the fire. It is difficult in a great many boilers to keep this seam tight, owing to stresses created through the mode of firing.

THOMAS A. RAY.

Boston, Mass.

* * *

The Staten Island Explosion*

There seems to be some doubt in the minds of those who have investigated this accident as to its cause. While it appears to have been found that the lower bumped head of the mud drum was slightly weakened by corrosion and possibly the metal of the head at the turn of the flange damaged by a breathing action, there was apparently sufficient metal left (assuming its strength was not seriously impaired) to have successfully held the head unless it had been subjected to a shock.

The theory has been advanced that the braces attached to this lower head may have been broken, due to overload or to defects in the brace material, and in breaking have thrown a sudden load on the head which it was not able to withstand. This is a plausible explanation, and one that appeals to the writer as possibly being the best to explain the accident.

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*See "Power," Nov. 4, and Dec. 30, 1913.

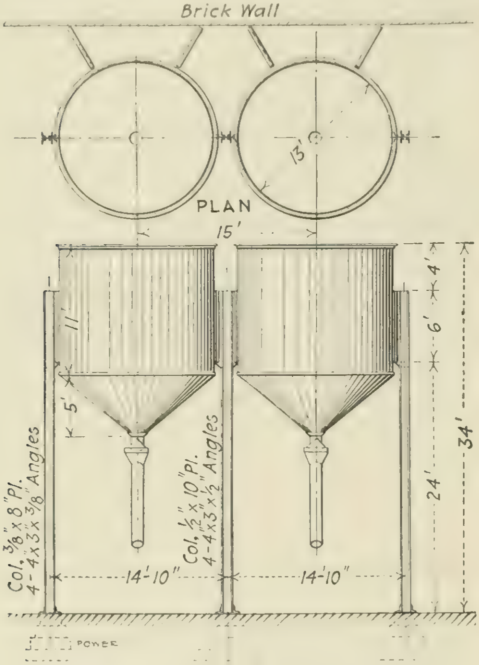
There is, however, another reasonable explanation. The boiler, being of the vertical type, was probably subject to vibration due to pulsations in the steam line, which may have weakened the connection to the steam main or have caused the failure of some pipe fitting near the connection to the boiler. If a break at the main steam connection had caused an opening of considerable size to be suddenly formed in or near the top drum, the result would doubtless have been a sudden rise of water level (filling the steam drum) and this would have produced a water-hammer effect in the mud drum, with the force exerted in a direction tending to knock out the bottom head. It is fairly common to find the plate material in the vicinity of steam-pipe connections on boilers damaged by vibrations of the steam line; and often such vibrations cause injury or weakness in other parts of the boiler.

J. E. Terman.

Hartford, Conn.

Steel Coal Bins

About five years ago the writer designed a steel coal bin for overhead storage that certainly has one thing to recommend it—cheapness. At the time, there was some opposition to the design, but it has given satisfaction.


Brick Wall
PLAN
13'
15'
11'
5'
4'
6'
24'
34'
14'-10"
14'-10"
Col. 3/8"x8" Pl. 4-4x3x3/8" Angles
Col. 1/2"x10" Pl. 4-4x3x1/2" Angles
POWER

Method of Supporting Bins

As shown in the drawing the bins are 13 ft. in diameter with sides 11 ft. high and a 5-ft. hopper bottom. They were erected in pairs, supported on three columns and tied at the top to the boiler-house wall with steel angles. Ten of these bins were erected, one for each boiler, and the total cost, including concrete footings, columns, gates and spouts was $6000, the work being done by contract. The capacity of one bin is 50 tons of bituminous coal. The plates in the sides and bottom are 3/8 in. thick. As erected, the columns had no bracing, the intention being to brace the columns after the gates and spouts had been satisfactorily located, but so far a the writer knows, the columns have never been braced. O course, should anyone remove the brick wall at the poin of lateral support the result would be bad.

C. O. Sandstrom.

Kansas City, Mo.

Engine Stopped When Speeded Up

Some time ago I was sent for by the owner of a 12-hp portable gasoline engine employed in driving a hay bailer The engine, of horizontal type and equipped with a gasoline pump and mixing valve, appeared to work all righ when running at low speed, but when speeded up i would slow down and stop after a few revolutions. Th usual routine of scraping all electrical connections, polishing contacts, etc., was resorted to, only to have the engine repeat its performance.

Looking over the gasoline pump, I found everythin apparently as it had left the factory; however, there wa considerable vibration as the engine began to increase it speed. After it had stopped, the puzzling part was th abundance of gasoline in the mixing chamber, indicatin that the pump was doing its work.

Then I decided to run the engine with the cover of th mixing valve removed and, as the engine started to spee up, all the gasoline vanished; as it slowed down again about the last two revolutions, the valve refilled. I nex cut a small piece of steel wire from a fish line and mad two spiral springs, placed them on top of the ball valve in the suction and discharge, the engine was started, an everything was all right.

The cause was that upon speeding up the engine th rapid oscillation of the pump piston lifted the balls o their seats and the vibration kept them rolling aroun the edge of the seats, making the pump lose what gasoline it had raised, but as the engine came to a stop th balls would roll back just in time to retain some gasolin in the mixing valve.

Frank Hudson.

Ager, Calif.

Criticises Company's Attitude

An article in the Jan. 6 issue shows how the engineer and firemen are regarded by some big manufacturin companies. Mr. Hickstein says: "There was no mone to establish a bonus system," to stimulate the firemen t better work. Concluding, he says that the recorders, b means of posting each man's record, have saved the company an average amount on the daily coal bill sufficien to pay the firemen's wages.

Now this amount, it might be said, represents clea profit to the manufacturers and instead of dividing evenly, by means of a bonus system, with the men who ar making this profit possible, they want it all.

Mr. Hickstein says these firemen are nearly all "illiterrate foreigners with no hope of advancement." Is thi same company, that is big enough to have an annual coa bill of $250,000, spending anything to develop thes foreigners by furnishing reading and study courses, etc. so they may gain some hope for advancement?

H. U. Cooper.

Kasson, Minn.

Experiences of a Gasoline-Engine Trouble-Man

A contracting concern purchased a 20-hp. gasoline engine from a manufacturer located in western Pennsylvania. When the engine arrived it was set up and started. The purchaser got the idea that the spark plug furnished was inferior as compared with another which he had been using and he accordingly bought one and used it in the engine, or rather tried to use it, in place of the one furnished. The owners fooled with the engine for two days and then telegraphed to the manufacturer that the engine would not run and to send a man to fix it.

This man found that when the compression relief cock was open for starting, the charge in the cylinder would explode, but when the engine approached anything like full speed, it would suddenly stop. He removed the spark plug, found the terminals about $\frac{5}{32}$ in. apart, and, having bent them together until they were separated about $\frac{1}{32}$ in., he replaced the plug. The engine was then started and ran all right. This man traveled over 30 hr. continuously to reach the customer, and all for about 10 min. work. He was absent from the shop for five days.

Another case of trouble encountered by this man on the same size and type of engine occurred in Montreal, in December. He started up and found that half load would slow the engine down to about half its rated speed and that three-quarter load would stall it. As the compression and ignition were all right, obviously the only trouble left to look for was in the mixture. He finally discovered that the piston was upside down, the engine being horizontal. As the engine operated on the two-stroke-cycle principle, this brought the deflector on the bottom and over the exhaust ports, preventing complete expulsion of the exhaust gases and proper scavenging of the cylinder. The piston was turned right side up, the cylinder head replaced and the engine carried its full load at its rated speed.

PHILIPS MIHLEDER.

Brooklyn, N. Y.

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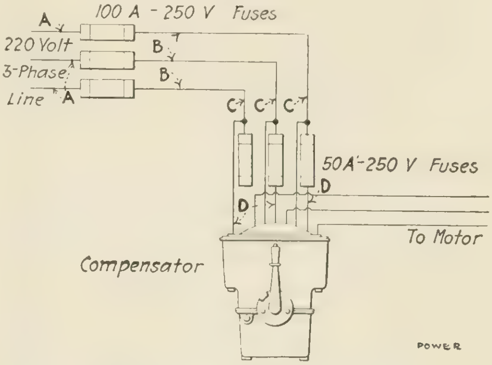
Unbalanced Phases with Induction Motor

In a test recently made upon a centrifugal pump direct connected to a three-phase induction motor it was necessary to measure the input into the motor. The motor is normally rated at 15 hp., at 220 volts and 35.5 amp. and is started with a compensator connected as shown in the illustration. The motor should have drawn about 10 amp. running light and about 16 amp. when connected to the pump, the pump being unprimed, at a balanced voltage of 220 between any two lines. On the test, however, the following results were obtained: Line voltages 220, 200 and 176, and line current (measured in one phase only) 35 amp.

The first conclusion was that the motor was running single phase, but it started all right and therefore three-phase current was being used. Next it was thought that a poor contact in the compensator was the cause, but the contacts were all cool. A voltmeter was used to trace out the trouble. Voltages at *A* and *B* were taken and found to be all right; also, voltages at *C* were found to be balanced and all equal to 220. With the motor running, the previous unbalancing was again found at *D*.

The motor was then stopped and the fuses removed. They were examined and the telltales were found unburned. Then the fuses were put in one at a time and the voltage measured from the line side of one to the motor side of the tested fuse. It was then found that one of them had burned out, leaving the telltale intact. The compensator, as is usual, starts the motor from the line side of these fuses so that the starting was from the three-phase line, but on the running position the blown fuse caused single-phase operation. Once started and up to speed any polyphase induction motor will run single-phase but at about double the three-phase current. It happened in this case that the ammeter was inserted in a live line.



MOTOR-STARTING CONNECTIONS

F. G. SWITZER.

Ithaca, N. Y.

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Carburetor Troubles

In his article on "Carburetor Troubles and Symptoms," in the Dec. 30, 1913, issue, A. L. Brennan stated that, "An over-lean mixture will often cause backfiring in the intake pipe or carburetor." This statement is correct but not complete. A backfire is caused by the introduction into the engine of a very slow-burning mixture, in which combustion occurs during the working stroke, the exhaust stroke and part of the admission stroke. Thus when the inlet valve opens and admission of fresh mixture occurs, it meets in the clearance space gases in which combustion is still going on, instead of products of complete combustion. These burning gases will, of course, ignite the incoming charge and cause a backfire.

Mr. Brennan seems to neglect the fact that over-rich, as well as over-lean, mixtures are slow burning, and are therefore just as likely to cause a backfire. It is a common mistake to attempt to distinguish between over-rich and over-lean mixtures, with regard to their effect on the proper running of a gas engine, but there is really little, if any, difference between them, from that point of view, except that an over-rich mixture causes a greater waste of fuel. Any gas present in the mixture, and not entering into the combustion, retards the velocity of propagation of the flame.

WILLIAM J. DEMOREST.

New York City.

Inquiries of General Interest

Approximate Rule for Engine Horsepower—What is a short rule for estimating the horsepower of a single-cylinder engine?

J. O. I.

Square the diameter of the cylinder in inches and divide by 2. The rule will be approximately correct for 35 lb. m.e.p., and a piston speed of 600 ft. per min., or whenever the product of the mean effective pressure and piston speed is approximately equal to 21,000.

Volumetric Efficiency and Compression Ratio in Gas Engines—What is the difference between volumetric efficiency and compression ratio as applied to the gas engine?

C. P. R.

Volumetric efficiency is the ratio of the volume at atmospheric pressure corresponding to the actual weight of mixture drawn in, to the volume equivalent to the piston displacement. It is dependent upon the density of the charge and the friction through the intake. The compression ratio, on the other hand, is the volume before compression divided by the volume after compression. It is dependent wholly upon the cylinder dimensions and clearance.

Stopping Cracks in Boiler Settings—How can the cracks of boiler settings be stopped up to prevent infiltration of air?

N. C. E.

To be permanently effective the material used for filling the cracks should be of such nature that it will adjust itself to subsequent expansion and contraction of the walls of the setting. For the purpose a semiplastic material such as loam and molasses, or tar with infusorial earth, or pulverized fillings of clay and infusorial earth confined by asbestos wool have been used. A method which has proved effective for closing small cracks from the outside of the walls is to cover the cracks with strips of muslin fastened with broad-headed nails and spread with a coating of thin plaster. Any filling or covering of the crevices should be done when the walls are cold.

Nonfreezing Compound—What is a good nonfreezing compound for water kept in barrels or buckets for use in case of fire and how can the water be kept sweet?

W. D. G.

Adding to the water 2 lb. of common salt, or of commercial chloride of calcium to each gallon of water will prevent freezing at temperatures down to about 15 deg. F., or lower, according to the strength of the solution. To prevent unpleasant odors arising from keeping the water a long time, the containing vessels should be perfectly clean before being filled, and when wooden barrels or buckets are used their interior should be charred. Use fresh, clean water, as free as possible of organic matter, and when the vessels are filled, sprinkle the surface of the water with crushed charcoal and protect the water from contamination.

Saving by Use of Feed-Water Heater—What saving of heat is obtained by using exhaust steam to heat feed water from 55 deg. F. to 204 deg. F., the boiler pressure being 100 lb. per sq.in.?

A. W.

The gain per pound of feed water would be 204 — 55 = 149 B.t.u. The heat required per pound of steam raised from 32 deg. F. to 100 lb. gage pressure (shown by steam tables) is 1188.8, hence with feed water at 55 deg. F., i.e.,

55 — 32 = 23 deg. F. above 32 deg. F.,

each pound of water, for conversion into steam at 100 lb. boiler pressure, would require 1188.8 — 23 = 1165.8 B.t.u., therefore the saving by use of the feed-water heater would be

$$\frac{149}{1165.8} \times 100 = 12.78 \text{ per cent.}$$

One Safety Valve Discharging through Another—When two safety valves are each set to blow off for 200 lb. per sq.in. gage pressure, the first valve discharging through the second valve, why is it that a pressure of 400 lb. per sq.in. gage pressure would be required on the underside of the first valve for discharge to take place through the second valve?

W. J. K.

For either valve to discharge, the pressure on its unde side would have to be 200 lb per sq in greater than the pressure into which it discharges, and as for discharge to tak place through the second valve, the pressure connecting th discharge side of the first valve with the underside of th second valve would have to be 200 lb. per sq in. above atmospheric pressure, then for both valves to operate at the sam time, the pressure on the underside of the first valve woul have to be 200 lb. per sq.in. + 200 lb. per sq.in. above atmospheric pressure, i.e., 400 lb. above atmospheric pressure.

Delivery of Pump—At 40 r.p.m. and allowing 7 per cent slippage, how many gallons of water would be delivered pe minute by a duplex pump having water pistons 8 in. in diameter by 10-in. stroke and piston rods 1¾ in. in diameter?

The area of an 8-in. diameter piston being 50.265 sq.in and the cross-sectional area of a 1¾-in. diameter piston ro being 2.405 sq.in., then, for each revolution of the pump there would be two piston displacements due to the full are of the piston with 10-in. stroke, or,

$$2 \times 50.265 \times 10 = 1005.3 \text{ cu.in. of piston displacement}$$

and also two piston displacements due to the area of th piston, minus the cross-sectional area of the piston rod, wit 10-in. stroke or

$$2 \times (50.256 - 2.405) \times 10 = 957.2 \text{ cu.in.}$$

of piston displacement.

Therefore the total piston displacement per revolutio would be:

$$1005.3 + 957.2 = 1962.5 \text{ cu.in.}$$

and for 40 r.p.m. and 7 per cent. slippage the delivery would be

$$93 \text{ per cent. of } \frac{1962.5 \times 40}{231} = 316 \text{ gal. per min.}$$

Horsepower of Vertical Boiler—What would be the horse power size of a vertical boiler containing forty 1½-in. tube 4½ ft. long and having a firebox 28 in. in diameter by 22 in high?

E. B.

The horsepower size of a boiler is based upon the numbe of square feet of heating surface. In a vertical boiler thi consists of the heating surface in the sides and tube sheet o the firebox, plus that in the tubes. The firebox being 28 in. in diameter its circumference would be

$$28 \times 3.1416 = 87.965 \text{ in.}$$

and being 22 in. high, then the area of the sides of the firebo would be

$$87.965 \times 22 = 1935.23 \text{ sq.in.}$$

The gross area of the firebox tube sheet would be

$$28 \times 28 \times 0.7854 = 615.75 \text{ sq.in.}$$

For each 1½-in. tube (the external diameter of a 1½-in. tub being 1½ in.), the area would be

$$1\tfrac{1}{2} \times 1\tfrac{1}{2} \times 0.7854 = 1.767 \text{ sq.in.,}$$

and there being 40 tubes, the total cros-sectional area of th tubes would be

$$1.767 \times 40 = 70.68 \text{ sq.in.;}$$

therefore, the net heating surface of the tube sheet would b

$$615.75 - 70.68 = 545.07 \text{ sq.in.}$$

The internal diameter of each tube being 1.31 in., its circumference would be

$$1.31 \times 3.1416 = 4.115 \text{ in.,}$$

and the length of the tubes being 4½ ft., or 54 in., the area o each tube would be

$$4.115 \times 54 = 222.21 \text{ sq.in.}$$

and the area of the 40 tubes would be

$$222.21 \times 40 = 8888.4 \text{ sq.in.}$$

Hence as

The area of the sides of the firebox = 1,935.23 sq.in.
The net area of the tube sheet = 545.07 sq.in.
The areas of all the tubes = 8,888.4 sq.in.

Total area = 11,368.7 sq.in.

Reduced to square feet, this would be

$$11{,}368.7 \div 144 = 78.9 \text{ sq.ft.}$$

and allowing 10 sq.ft. per horsepower the horsepower of th boiler would be

$$\tfrac{1}{10} \text{ of } 78.9 = 7.89 \text{ hp.}$$

Engineers' Study Course

The Slide Rule--III

Last Lesson's Answers

6. The problem as given cannot be solved at one setting. If the first term in the numerator and the denominator are interchanged, making the problem

$$\frac{0.492 \times 1.29}{33.4}$$

it can be solved at one setting as follows:

Remembering that the decimal points are not to concern us until the end of the problem, set the hair line over 492 on the D-scale. Do this by first moving the runner to 4. The number shows that we are to go $\frac{9}{10}$ of the distance to 5, so keep on moving the line, passing over the main divisions 41, 42, 43, 44, the longest line shown at 45, then on over 46, 47, 48 and, finally, stop at 49, within one more large space of 5. Now, to get $\frac{2}{10}$ of the remaining distance to 5, notice that there are only two small divisions, so each must represent $\frac{5}{10}$, hence $\frac{2}{10}$ will be $^2/_5$ of one of the smallest spaces at this part of the rule and must be guessed at. Leaving the runner at this point, move the slide until 334 on the C-scale comes under the hair line. First move the slide until 3 is under the hair line. Then counting the bigger divisions move the slide to the left until $\frac{3}{10}$ of the distance to 4 is covered, that is, passing 31, 32 and stopping at 33. The slide must go still further to the left, but not so far that 34 will be under the hair line. It is to go only $\frac{4}{10}$ of the distance between 33 and 34. As this distance is divided into five spaces, each space represents $\frac{2}{10}$, and the slide is to be moved still farther until the second short line on the C-scale after 33 is under the hair line. This is the only setting of the slide. The answer will be found under 129 on the C-scale. Move the hair line first to the second marked or numbered division on the C-scale from the left-hand "1." This will be 12. (On some rules it is marked "1.2"; on others simply "2.") There are ten divisions between 12 and 13, so that nine of them are to be passed over in setting the hair line at 129. In the proper position the hair line will be just one of the smallest spaces to the left of 13 on the C-scale.

The answer on the D-scale is closely 19, as near as it can be read and well within the limit of the accuracy of the rule. Now to locate the decimal point. Inspection of the numerator shows it to be approximately 0.5 and 33 will not go into it until it is multiplied by 100 or the decimal point moved two places to the right. The first figure in the answer will, therefore, come in the second place after the decimal point, or 0.019 is the answer.

7. Following the rule "set the first on the second under the third find the fourth"; first place the hair line over 408 on the D-scale. Slide it at once to 4. It must not go one of the larger divisions farther, as that would be 41, and 408 is $\frac{8}{10}$ of the distance between 4 (or 40) and 41. The smaller divisions are $\frac{5}{10}$ of the next larger, so the hair line is to be moved one whole small division to the right from 4 and then over $^3/_5$ of the next space to estimate 408. Leaving the runner here, move the slide until 61 on the C-scale is under the line (61 is one of the larger, or two of the smallest spaces to the right of 6). Now, leaving the slide set, move the runner to 32 on the C-scale (32 is two of the larger, or ten of the smallest spaces to the right of 3). Under the hair line on the D-scale is the answer which is seen to be something between 2 and 3, and as it comes in the second large division, is between 21 and 22. It is practically on the line between the second and third smallest divisions. As each of these smallest divisions represents $\frac{2}{10}$, the answer is $\frac{4}{10}$ more than 21, or 214, and it can plainly be seen that it is a whole number, the decimal going after the 4.

8. Let us examine the old familiar horsepower formula:

$$hp. = \frac{PLAN}{33{,}000}$$

Evidently increasing the mean effective pressure, or the length of stroke or the area of the cylinder or the number of strokes per minute would increase the value of the fraction and make the horsepower larger. It is stated that the pressure remains the same; the length of the stroke and area of the cylinder must also. The only quantity that changes is the strokes per minute, and just as this changes the horsepower changes, so the problem may be solved as a simple proportion, thus,

$$160 : 45 : : 200 : x$$

Set the hair line on 45 on scale D (midway between "4" and "5"). Move the slide to the right until 16 on scale C is under the line (16 is the end of the sixth large division between "1" and "2"). The answer is on D under "2" on C. It is found to be between "5" and "6" and between 56 and 57 and about ½ of the smallest division after 56. Each of these smallest divisions being $\frac{5}{10}$, the answer is ¼ more than 56, or 5625, and the decimal point, as may be seen by inspection, belongs after the 6, making the answer 56.25 hp.

9. The number 42,200 has an odd number of integers, therefore the left-hand A-scale is to be used. Set the hair line on 422 on the A-scale. (First set the line on "4." Then move it two large or four of the smallest divisions to the right. This is 42. Then as each of these smallest divisions is $\frac{5}{10}$, the line is to be moved $^2/_5$ of one of these divisions farther to the right. This distance must be estimated.) Under the hair line on scale D is the square root, which is more than 2 and less than 21; it is a little over 205 (each of the smallest divisions being $\frac{2}{10}$). Evidently the hair line divides the smallest division within which it falls into about $\frac{6}{10}$ and $\frac{4}{10}$, and as the division represents 2, $\frac{6}{10}$ of 2 = $^{12}/_{10}$ of 1. Hence, as close as can be estimated, the answer is 2052 and, pointing off the original number by "twos" of places as 4′22′00, there will be three whole-number places in the square root, making it 205.2. (More exactly the answer is 205.4264.)

10. Invert the slide in the rule so that the numbers on

the slide are upside down with respect to those on the rule. Point the number off in units of three places, as 42,200. The answer is to have two whole number places and the first figure is to be the cube root of the largest number less than 42. Evidently then it will be 3, for 3 × 3 × 3 = 27, while 4 × 4 × 4 = 64. This shows around what point on the rule the answer is to be looked for, so that there need be no danger of the confusion mentioned in the last lesson. Set 422 on the right hand A-scale just as it was set in the last problem on the left-hand A-scale. (On some rules the "1" is marked "10" on the right hand scale.) Bring the right hand "1" of the C-scale to this point. Now move the runner until the hair line covers the same number on the D-scale and the upside down B-scale. When the line is over the "3" of the B-scale, it is over 375 of the D-scale, so it should go farther to the left. At 31 on *B*, 369 is covered on *D*. At 32 on *B*, 357 on *D*. At 34 on *B*, 352 on *D*. At 345 on *B*, 35 on *D*. Evidently 3485 is as close as the cube root can be estimated, and it will have only two places; therefore, 34.85 is the cube root of 42,200. (More exactly the cube root is 34.8154.)

THE SLIDE RULE CONTINUED

Another useful application of the rule with the slide inverted is in the dividing of a given number by any number at one setting. This is evident from the fact that the inverted slide gives reciprocals, for, in the normal use of the rule, the product of a given number and any other number is obtained at a single setting. Suppose, as in the compiling of a table, it is desired to divide a certain number by each number in a column of numbers.

For instance, a tank holds 12,000 gal., and it is desired to know how many minutes it will take to discharge it at various rates of discharge.

Set the left-hand "1" of the inverted C-scale on 12 of the D-scale. Then under any number on the C-scale (inverted) will be found on the D-scale the quotient of 12,000 divided by the C-scale number.

For instance, if the rate of discharge is 40 gal. a min., the time to discharge 12,000 is 300 min., and so a table could be constructed with one setting of the slide by simply moving the runner.

Gal per Min	Discharging Time in Min.
40	300
80	150
120	100
160	75
200	60
240	50
280	42.8
320	37.5

Often it is hard to make an exact setting on the rule where much of the number has to be estimated. If a factor of that kind is to be used frequently, so as to warrant it, an equivalent ratio may be found that is more readily set. The number π (3.14159) is so often used that some rules have a line for that number, but if they have not, if 226 of the C-scale is set on 710 of the D-scale, under the left-hand "1" of the C-scale will be π (3.14159) on the D-scale. At this setting of the rule the circumference of a circle of any given diameter may be found on the D-scale under the corresponding diameter on the C-scale.

A number of these equivalent ratios for conversion factors, such as are usually given on the backs of slide rules, are herewith tabulated. Remembering the proportion rule, "On the first set the second, &c.," any of these conversion ratios may be used.

$$\frac{226}{710} = \frac{\textit{diameter of circle}}{\textit{circumference of circle}}$$

$$\frac{40}{9} = \frac{\textit{circumference of circle}}{\textit{side of inscribed square}}$$

$$\frac{39}{11} = \frac{\textit{circumference of circle}}{\textit{side of equal square}}$$

$$\frac{70}{99} = \frac{\textit{side of square}}{\textit{diagonal of square}}$$

$$\frac{11}{14} = \frac{\textit{square inches}}{\textit{circular inches}}$$

$$\frac{300}{191} = \frac{\textit{area of circle}}{\textit{area of inscribed square}}$$

$$\frac{5}{127} = \frac{\textit{inches}}{\textit{millimeters}}$$

$$\frac{292}{89} = \frac{\textit{feet}}{\textit{meters}}$$

$$\frac{35}{32} = \frac{\textit{yards}}{\textit{meters}}$$

$$\frac{87}{140} = \frac{\textit{miles}}{\textit{kilometers}}$$

$$\frac{31}{200} = \frac{\textit{square inches}}{\textit{square centimeters}}$$

$$\frac{140}{13} = \frac{\textit{square feet}}{\textit{square meters}}$$

$$\frac{61}{51} = \frac{\textit{square yards}}{\textit{square meters}}$$

$$\frac{36}{590} = \frac{\textit{cubic inches}}{\textit{cubic centimeters}}$$

$$\frac{106}{3} = \frac{\textit{cubic feet}}{\textit{cubic meters}}$$

$$\frac{6700}{29} = \frac{\textit{cubic inches}}{\textit{U.S. gallons}}$$

$$\frac{234}{1750} = \frac{\textit{cubic feet}}{\textit{U.S. gallons}}$$

$$\frac{3}{85} = \frac{\textit{cubic feet}}{\textit{liters}}$$

$$\frac{280}{127} = \frac{\textit{pounds}}{\textit{kilograms}}$$

$$\frac{62}{63{,}000} = \frac{\textit{tons}}{\textit{kilograms}}$$

$$\frac{128}{9} = \frac{\textit{pounds per square inch}}{\textit{kilograms per square centimeter}}$$

$$\frac{13}{30} = \frac{\textit{pounds per square inch}}{\textit{feet of water}}$$

$$\frac{970}{66} = \frac{\textit{pounds per square inch}}{\textit{atmospheres}}$$

$$\frac{174}{850} = \frac{\textit{pounds per square foot}}{\textit{kilograms per square meter}}$$

$$\frac{17}{1060} = \frac{\textit{cubic feet of water}}{\textit{pounds of water}}$$

$$\frac{51}{1440} = \frac{\textit{cubic feet of water}}{\textit{kilograms of water}}$$

$$\frac{340}{47} = \frac{\textit{foot-pounds}}{\textit{kilogram-meters}}$$

The manuals that deal with the slide rule usuall give still more of these factors and the reader can readil figure out his own for any special problem he may have.

Tests of Four-Pass Boiler with Illinois Coal

The second of the informal dinner discussions of the Chicago Section of the American Society of Mechanical Engineers was held in the Crystal Room of the Hotel Sherman, Chicago, Ill., on the evening of Jan. 28. The meeting was attended by 140 members and guests and was opened by the chairman of the local committee, Paul P. Bird. The paper of the evening, by Bryant Bannister, dealt with a series of boiler tests with Illinois coal and was in substance as follows:

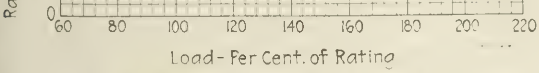
In April of 1913 a new boiler house was completed at the works of National Tube Co., at Kewanee, Ill., and a series of tests, ranging in length from 4 to 24 hr., and with loads varying from 75.6 to 205.2 per cent. of rating, were conducted.

In order to eliminate error in estimating the amount of coal on the grate it was thought best to conduct a test of much longer duration. The data obtained from the first eleven tests, therefore, are given out at this time only as corroborated by the results obtained in a 72-hr. test completed Oct. 30.

The complete boiler plant consists of four Edge Moor water-tube boilers, each set as a unit, having 20-ft. tubes, and baffles arranged to give four passes for the gases, with the stack outlet at the bottom of the fourth pass. Each has 6132 sq.ft. of heating surface and 1200 sq.ft. of superheating surface, Foster superheaters being installed. Each boiler is set with the bottom of the front header 8.67 ft. above the level of the dumping plate of the stoker, thus giving the large combustion chamber so essential to the thorough combustion of highly volatile coals. The firing is done by a seven-retort Taylor stoker equipped with an air extension grate. Each stoker has its own fan and engine.

Much was done to make each boiler setting tight and as free from radiation losses as possible. The setting was first coated with a thick asbestos paint, and then covered with 1½ in. of 85 per cent magnesia, and finally with muslin and again painted to insure against air leakage. The headers were also covered, where exposed, with this same magnesia compound, and the whole setting top was covered with a three-inch layer of firebrick and cement, and then with the magnesia covering. At no time during the tests was the setting more than warm, even at the highest loads.

Gland leakage on the feed pump was weighed and accounted for and no blow-downs were made during any of the tests. The safety valves on the test boiler were set several pounds above those on the remaining boilers, but at the higher rates of evaporation pop-offs were unavoidable; these were carefully timed and accounted for.



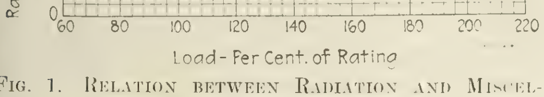


FIG. 1. RELATION BETWEEN RADIATION AND MISCELLANEOUS LOSSES AND LOAD

Flue gases were drawn from the bottom of the fourth pass and analyzed by an Orsat apparatus. Since each boiler unit has its own stack it was further possible to properly regulate the air supply to the stoker by observing the smoke condition. As shown by the data, the furnace draft was maintained as low as possible.

Referring to the first eleven tests, made earlier in the year, the apparent disparity between efficiencies at similar loads is noticeable. There was considerable range in the moisture content of the coal samples, which was due largely to rainfall after the first three tests, much of the coal being exposed. Also, neither the quality of the flue gases nor the percentage of combustible in the ash forms any definite curve when plotted against the load. The heat balance gave little information other than that the tests were too short to be reliable if taken individually. Therefore, a second heat balance was created, based upon the average of those factors not influenced by the rate of firing, such as moisture, CO in the flue gas, and combustible in the ash. The dry flue gas loss was changed to correspond to the gas temperatures obtained from Fig. 2; and the whole was balanced with the radiation loss obtained from Fig. 1. The curve in Fig. 1 was assumed after careful comparison of the Kewanee boiler settings with those of the large units in the Detroit Edison plant. The setting comparisons were made upon a basis of exposed areas, temperature of exposed areas above boiler room, and character of setting wall, together with the relative rated capacities of the units. In effect it is thought that this created curve represents approximately what would be accomplished by tests of indefinite length, with coal of the average moisture, hydrogen, etc., as obtained during these tests, and with the same combustion as shown by the average of the gas and ash analyses for these tests.

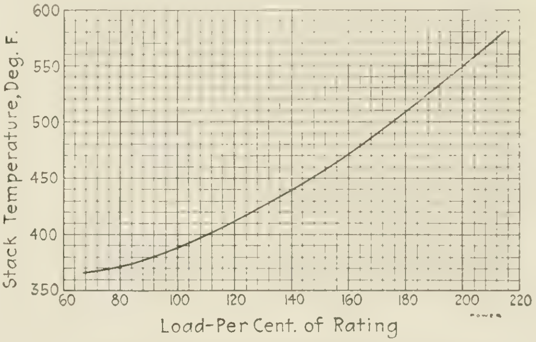


FIG. 2. STACK TEMPERATURE VS. LOAD

Referring to the actual heat balance for test number twelve, the 72-hr. test, it will be observed that the residue for radiation and miscellaneous losses falls upon the curve in Fig. 1.

TABLE I. HEAT BALANCE, EVAPORATIVE TEST NO 12

	B.t.u.	Per Cent.
Heat absorbed by boiler	8980	80.95
Loss due to evaporation of moisture in coal	231	2.08
Loss due to heat carried away by steam formed by burning of hydrogen	494	4.45
Loss due to heat carried away in dry flue gases	855	7.71
Loss due to carbon monoxide	35	0.31
Loss due to combustible in ash and refuse	223	2.01
Loss due to radiation and unaccounted for	276	2.49
Calorific value of 1 lb. of dry coal	11,094	
Total		100.00

DISCUSSION

H. P. BRYDON thought that the Kewanee Works had shown courage in installing a type of stoker which had made its chief success with the higher grade coals of the East, and expressed curiosity as to what part the stoker played in attaining the high efficiencies.

He also thought that the steam consumed by the stoker engines and by the soot blowers should be deducted from the total, and further expressed the opinion that the four-pass design and the heavy lagging were largely instrumental in attaining the high efficiency.

R. H. KUSS submitted the following written discussion:

Even without correction or adjustment the efficiency results are exceedingly good. Certain critical items of the series of tests can be picked out to advantage. One of these is the low gas exit temperatures which indicates high heat absorption. This is particularly accounted for by the baffling.

During the 72-hr. test (No. 12) temperature readings were taken regularly at points above and below the fourth pass. The averages of the calibrated readings showed a temperature difference of 67.4 deg. F., which indicates a heat absorption of a little above 2 per cent. of the heat value of the fuel.

If it is conceded that the last pass is responsible for the amount of heat saving, an appreciable amount above that usually encountered with standard three-cross pass boilers is still to be accounted for. The conclusion is inevitable that the baffling of the first three passes contributes in no small degree to the general high efficiency results, or a temperature as low as 359 deg. F. would not have been encountered at the end of the third pass, even crediting the setting with special provisions against radiation and air leakage. It is clear that for good absorption results, 18-ft. tubes are not necessary for three-pass boilers, provided the baffling is such as to employ the heating surface to advantage.

It is obvious that the tube proportions could not have been duplicated without the inclined first flame plate, and this test series, combined with the close scrutiny of many other four-pass installations, leads to the conclusion that it is not possible to create a successful four-pass setting with all of the baffling at right angles to the tubes, even when using 20-ft. tubes, unless the setting is to sacrifice a large part of its elasticity in capacity possibilities. If this conclusion is correct, then security must be had against baffle leakage and general baffle deterioration. The use of tile resting against metal supports in an inclined position is not successful in the construction of the inclined flame plates. Recourse is best taken to building the first flame plate by the older, more costly and perhaps less attractive, method of "grouting" in position baffles made up of plastic refractory material reinforced with metal as was done at Kewanee. That this method made possible the location and protection of soot blower pipes is worthy of note, although the main reason for the selection of this construction came from a desire to create a tight baffle in an inclined position.

Aside from the greater economy in the absorption of heat due to four passes in place of three passes, several other important advantages may be mentioned; these are:

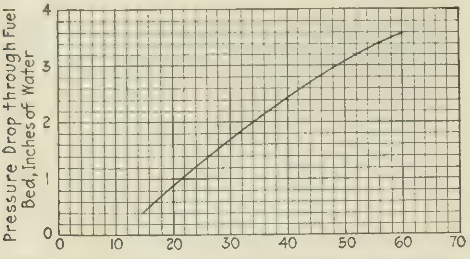


FIG. 3. EFFECT OF RATE OF FIRING ON PRESSURE DROP THROUGH FUEL BED

1. The breeching is below the boiler; consequently the boiler-room roof may be lower than for a three-pass setting. The breeching is out of the way of piping, and heated air surrounding the breeching due to radiation can be carried direct to the furnace beneath the boiler-room floor, making the boiler-room cooler.

2. The cleaning of soot from the tubes may be done more effectively because the gas passages are less in width.

3. Where the plant arrangement permits, the space between the normal boiler-room floor and the rear boiler header can be used for breeching construction. Almost the entire setting behind the furnace bridgewall is of little use in the three-pass setting; the brick cost, air infiltration and radiation losses of these walls can be largely done away with by constructing the breeching immediately behind the furnace bridgewall. By the same design there is created a boiler room floor level behind and between the settings, from which soot blowing, washing, blowing down, etc., can be accomplished without the use of platforms or ladders. The disadvantage of two elevations disappears if the engine room floor is of a higher elevation than the boiler room, and provided that the engine room is located behind the boiler room. The setting cost plus the breeching cost is less than for a normal three-pass setting plus a breeching.

A. BEMENT wished to know whether the total or the available hydrogen contained in the coal was considered when calculating the loss due to the water formed by this constituent in the products of production. He also asked how the fires were cleaned and how often, and commented on the tendency to get low heat measurements with low capacities and high measurements with high capacities, due to the changing of the center of gas travel with different velocities and volumes. He believed the present tendency favored the four-pass arrangement and stated that he had even gone to the extent of designing a five-pass boiler with 18-ft. tubes, although perhaps in such a design a 20-ft. tube would be more desirable.

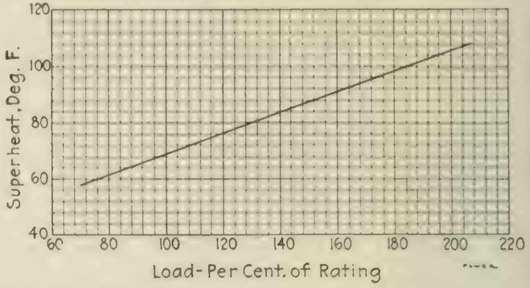


FIG. 4. RELATION BETWEEN SUPERHEAT AND LOAD

JOSEPH HARRINGTON submitted a written discussion in part as follows:

A perfect furnace would completely burn all the combustible in the coal fired with just the theoretical amount of air. With no losses due to combustible in the ash, CO in the furnace gases or excess air, the furnace efficiency would be 100 per cent. A perfect furnace and a perfect boiler would not, however, give 100 per cent. combined efficiency; first, because coal is not a perfect fuel, and second because the gases must escape at a temperature at least equal to the steam temperature, which is always higher than the surrounding air.

The magnitude of these necessary losses depends upon the amount of moisture and hydrogen in the fuel, the boiler pressure, and the temperature of the air in the boiler room and until they are known, and a proper allowance for their effect is made, a test cannot be scientifically analyzed or two tests compared. For instance, a test at 78 per cent. combined efficiency may be a better performance of both the boiler and furnace than another at 80 per cent. under different conditions, because the necessary losses might be more than enough to account for this difference.

After deducting the necessary losses per pound of coal as fired from the B.t.u. as fired, there remains an amount of heat all of which a perfect boiler and furnace could utilize. The ratio of the amount of heat theoretically avail-

TABLE 2. TESTS OF EDGE MOOR WATER-TUBE, FOUR-PASS BOILER

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 7	Test No. 8	Test No. 9	Test No. 10	Test No. 11	Test No. 12
Duration, hr	8	8	8	8	24	8	8	8	8	4	8	72
Steam pressure, lb.	112.1	115.1	112.3	118.5	116.0	113.7	116.0	111.9	115.8	122.9	112.4	117.3
Temperature of feed water, deg. F.	193.6	189.6	189.4	185.3	183.9	187.3	187.1	189.4	189.9	184.0	192.1	194.9
Temperature of gases leaving boiler	404	434.3	428.2	479.2	450.1	421.2	418.8	359.0	459.1	510.3	376.1	412.0
Draft in furnace	0.042	0.043	0.023	0.027	0.014	0.028	0.025	0.031	0.029	0.056	0.012	0.011
Blast pressure under grate	1.69	2.07	1.86	2.48	1.80	1.17	1.45	0.60	1.96	3.31	0.63	1.95
Deg. of superheat	60.5	82.5	83.5	80.8	91.2	82.3	77.7	61.1	84.7	105.3	59.2	77.9
Moisture in coal per cent.	12.81	11.63	11.41	13.10	14.08	13.86	15.63	15.51	13.63	15.76	15.77	16.15
Percentage of ash and refuse in dry coal	24.90	24.57	24.38	22.29	24.48	22.36	22.12	21.49	23.85	19.26	21.46	20.98
Dry coal consumed per sq.ft. of grate surface per hr.	30.2	37.4	34.6	44.6	32.5	24.2	28.7	17.3	39.3	56.6	18.8	28.5
Equivalent evaporation per hr. from and at 212° per sq.ft. of water heating surface	3.37	4.05	3.88	4.64	3.69	2.81	3.46	2.19	4.35	5.92	2.18	3.28
Horsepower developed	715.3	860.8	824.6	984.4	784.1	596.8	734.9	466.2	922.2	1258.4	463.8	695.6
Per cent. of rated capacity developed	116.7	140.4	134.5	160.5	127.9	97.3	119.8	76.0	150.4	205.2	75.6	113.4
Water fed per lb. of coal fired	7.13	6.94	7.2	6.51	7.00	7.21	7.35	7.84	6.91	6.27	7.19	7.022
Equivalent evaporation per lb. of dry coal	8.97	8.73	9.04	8.37	9.15	9.33	9.70	10.21	8.90	8.42	9.36	9.254
Equivalent evaporation per lb. of combustible burned	12.19	11.82	12.19	10.97	12.11	12.02	12.45	13.01	11.69	10.43	11.92	11.711
Calorific value of 1 lb. of dry coal, B.t.u.	11,325	11,318	11,211	11,290	11,048	11,282	11,335	11,488	11,303	11,844	11,598	11,094
Calorific value of 1 lb. of combustible, B.t.u.	14,454	14,398	14,325	14,032	14,123	14,175	14,088	14,227	14,209	14,296	14,331	13,773
Efficiency of boiler furnace and grate	76.87	74.92	78.27	71.98	80.38	80.27	83.05	86.32	76.47	69.02	78.36	80.95

able to that contained in a pound of coal as fired is the "ideal efficiency" and should form the basis for all analyses of results.

The ideal efficiency for the Kewanee test is about 89 per cent. The combined efficiency of 80.95 per cent. is, therefore, about 91 per cent. of that theoretically possible and 91 per cent. is, therefore, the real measure of the performance or actual efficiency of the unit. Fig. 1 has been assumed from a comparison of the Kewanee setting with the Detroit Edison installation, but in this comparison the most important feature has been overlooked, namely, the relative size of the combustion chambers, the Detroit boilers having furnaces of much larger volume per pound of combustible burned.

A definite time is required for the complete mixing of the oxygen with the combustible and if the rate of combustion is too high, the mixing and burning are not completed before the gases reach the cooling surface of the boiler and are cooled below the ignition point. A loss then results which cannot be accounted for and is not necessarily detected in the gas analysis. In reality this is a furnace loss, but in the absence of an accurate means of determination, it is of necessity included in the miscellaneous losses.

Volume alone is not the controlling factor in the value of a furnace. Its cross-section proportions are of primary importance, as a sufficient distance from the fuel bed to the tube line is essential for proper combustion. As long as the furnace efficiency remains constant, the principal factor tending to reduce the combined efficiency is the flue gas temperature, and the capacity-efficiency curve will approximate a straight line with a slight downward slope in the direction of increasing capacity.

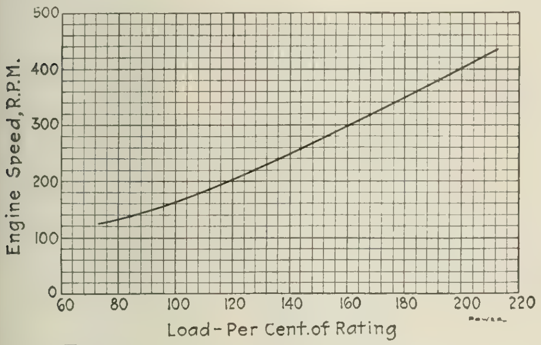


FIG. 5. SPEED OF FAN VS. LOAD ON BOILER

The Kewanee tests differ from the Detroit tests in that at Kewanee the most efficient furnace capacity was exceeded above 120 per cent. of rating, whereas at Detroit the limit of efficient furnace capacity was not reached at 200 per cent. The most noticeable point of excellence at Detroit was the large combustion chamber, whereas at Kewanee it was the low flue-gas temperature.

The first eleven tests were of too short duration to insure accurate results. Mr. Bannister recognized this and ran test No. 12 for 72 hr. to eliminate the errors due to starting and stopping. This test checks very closely with the average of the shorter tests.

The number of boilers in service should be such that each operates at or near its point of maximum efficiency, if the load on the entire station is practically constant; but as this is seldom the case, a certain range of unit capacity is necessary. When the point is reached where further decrease in unit capacity causes a decrease in efficiency, which will more than offset the loss of banking one boiler over the period of low load, banking should begin. With increasing load, additional boilers should be put on as soon as the load becomes large enough to permit their efficient operation. This affords protection against an unexpected or early increase in load and also has every boiler thoroughly warmed up and all fires in good condition before the peak load comes on. For short peaks it will usually be found most economical to drive boilers to their maximum capacity, even if this is above the limit of efficient operation.

A high efficiency test like the one under discussion, does not guarantee low steam cost in yearly operation. Of greater importance is the maintenance of those conditions that contributed to the high efficiency. The apparatus here described could be so operated as to offset its inherent efficiency, so that the annual steam cost is really a factor, not only of the apparatus efficiency, but of the efficiency of the boiler room organization.

F. C. GASCHE believed the success of Mr. Bannister, in using a coal containing approximately 20 per cent. ash and 15 per cent. moisture with a boiler and furnace efficiency exceeding 80 per cent. to be without precedent in steam engineering in this region. He mentioned that if the accumulating deliveries of fuel and water are recorded graphically with possibly hourly corrections for water levels, etc., there can be shown two curves for which an average inclination can be assigned. About ten years ago he had succeeded in obtaining 78 per cent. overall efficiency with dust fuel and a special type of furnace in connection with a water-tube boiler. Owing to difficulties in maintaining the furnace construction the process did not, at that time, develop into a commercial success but the investigation indicated that under proper furnace conditions, it was possible to burn Illinois coal with its encumbrance of 18 per cent. ash and about 14 per cent. moisture with an excess air supply scarcely exceeding 12 per cent. of the theoretical requirements.

J. C. BANNISTER, manager of the Kewanee Works, stated that the problem was to use a cheap available coal of poor quality without too much hand labor. The load conditions at the plant are favorable and a maximum load of 150 per cent. of rating is all that is required. He gave the following operating figures for the months of October, November and December, where conditions were unfavorable in that the plant was working irregularly. The average coal consumed per boiler horsepower-hour was for October, 4.53 lb., November, 4.70 lb. and December, 4.49 lb. The overall efficiency as calculated from the coal weights and water fed were for October, 77.7 per cent., November, 76.3 per cent., December, 78.5 per cent. The average load per boiler was for October, 721.8 hp., November, 565.4 hp., December, 656.8 hp.

In closing Mr. Bryant Bannister stated that the capacity test had not extended beyond four hours because the fan engine was not in good condition and it was deemed dangerous to operate it at the high speed (over 400 r.p.m.) for a much longer period. He stated that no furnace trouble was had during the high rate of driving. The clinkering took the form of a slagging process and the ash and refuse seemed to flow to the pit when the dumping plates were lowered. He did not know what the steam consumption of the soot blowers was, but did not believe it amounted to much. In answer to Mr. Bement he stated that the total hydrogen content was employed in calculating the losses due to the formation of water in the flue gases.

NEW PUBLICATIONS

THE MECHANICAL WORLD POCKET DIARY AND YEAR BOOK FOR 1914. Three hundred and eighty-eight 4x6-in. pages; 82 illustrations; indexed. Price, 25 cents. Norman Remington & Co., Baltimore, Md.

The 1914 edition of this well known pocket book is in keeping with the excellence and low cost of those of the years before. The matter has been increased by rewriting the section on steam turbines, adding a new section on the use of the miller and gear cutter, and fresh material on grinding. New tables include the dimensions of keys, hydraulic packing, copper expansion joints, the weight of octagonal iron and steel, weights of finished nuts, setscrews, and the like.

HANDBOOK OF ELECTRICAL METHODS. Published by McGraw-Hill Book Co., New York. Size 6x9 in.; 285 pages, illustrated. Price, $3 net.

Realizing that much useful material in a technical paper is discarded through failure of the reader to keep files or clippings, the publishers have selected a large number of short practical items from the issues of the "Electrical World" for the past three or four years. These have been classified under headings such as line construction, meters, operation of circuits, switchboards, lighting, signal bells, transformers, motors, generators, etc., and compiled in book form. The great variety of subjects presented and the concise treatment make the book interesting as well as useful to the operating man.

The Effects of Ice on Stream Flow—The design, installation, and operation of any plant that depends for its success upon flowing water demands a knowledge of the total flow of the stream and its variation throughout the year. The United States Geological Survey has been compiling for years stream-flow records for many streams in the United States and the methods of collecting such records for open water periods have been standardized, but during the winter the presence of ice affects the flow so much that the laws of flow pertaining to open channels are not entirely applicable, and no standard methods for collecting and interaffecting the data of that season have been recognized. In many localities ice persists in the streams for periods ranging from a few days to several months, and although the conditions resulting from ice are most pronounced in northern regions they are prevalent over wide areas, especially at high altitudes.

Recent studies made by the Geological Survey have added much information in regard to the factors influencing stream flow when ice is present, and with a view to standardizing as far as practicable the methods for ascertaining winter flow, Water Supply Paper 337, entitled "The Effects of Ice on Stream Flow," by William Glenn Hoyt, has been published and is available for free distribution. This paper discusses the factors that influence the run-off during the periods of low temperature, the varieties of ice and their effect on the applicability of the laws of open-channel flow, and the collection and interpretation of necessary data.

A copy of the report may be obtained free on application to the Director of the Geological Survey, Washington, D. C.

SOCIETY NOTES

The annual banquet of the Engineers' Society of Western Pennsylvania was held at the Hotel Schenley, Pittsburgh, Penn., the night of Feb. 6, with 725 at the tables. John Mapes Dodge, editor of "St. Nicholas Magazine," acted as toastmaster. Major-General Leonard S. Wood, chief of staff, United States Army, was to have been the principal speaker, but was kept in Washington by important army measures coming up in Congress. Rear-Admiral S. A. Staunton, U. S. N.; President Alfred H. Smith, of the New York Central R.R., and Dr. S. A. Bolles, president of Haverford College, were among the speakers. Admiral Staunton devoted his talk exclusively to the development of the navy from the days of the old wooden type up to the contemporary mass of great scientific machinery. President Smith paid tribute to the members of the society, praising their work in the development of the railroads of the world and of their activities in all branches of industrial progress. He deprecated the criticism of all railroads because of the sins of the few and said that next to agriculture the railroad had done more for the development of the nation than any other single factor. He inveighed against government ownership of utilities and said the experience of France in this respect should teach a lesson. Dr. Bolles compared the new currency law with the original national bank enactment. He was doubtful if the several regional banks would be able to obtain as much gold as may be needed to afford relief when desired. The act, he said, was a distinct improvement over the Aldrich system. The ideal banking system he declared would exist only after the Federal Government took complete control of the central bank. Among those at the speakers' table were: Alva C. Dinkey, president of the Carnegie Steel Co.; Congressman James Francis Burke; E. M. Herr, general manager of the Westinghouse Machine Co.; J. M. Dodge, Philadelphia; A. R. Raymer, president, the Engineers' Society; Colonel J. M. Schoonmaker, vice-president, the Pittsburgh & Lake Erie R.R.

PERSONALS

John S. Leese, engineer, has resigned his position with the British Westinghouse Co., Manchester, England, and joined the Osborne-Peacock Co., one of the leading firms of advertisers' agents in that country. Mr. Leese will develop and manage a technical and engineering department, with headquarters in Manchester.

Ernest S. Suffern is president of the Suffern Engineering Corporation which has taken over the business heretofore conducted by Suffern & Son, Singer Building, New York City. The corporation's practice will cover services in connection with organization and management, design, construction and equipment of plants, valuation of properties, and the effective operation of companies.

Prof. A. R. Acheson, head of the department of mechanical engineering at Syracuse University, has been appointed consulting engineer for the bureau of gas and electricity, Syracuse, N. Y. He will not sever his connection with the university. Prof. Acheson was selected because of his personal qualifications as an expert on matters handled by the bureau.

OBITUARY

FRANKLIN PHILLIPS

After a brief illness, Franklin Phillips, president of the Hewes & Phillips Iron Works, died suddenly of pneumonia at his residence, Newark, N. J., on Feb. 9. He is survived by a widow, a daughter and a son. Mr. Phillips was born in Newark in the year 1857, and was a son of the late John M. Phillips, founder of the Hewes & Phillips Iron Works, mechanical engineers and builders of the well known Hewes & Phillips Corliss engines. His education was received in the schools of Newark, the Stevens Institute of Technology, and finally Cornell University, where he graduated as a mechanical engineer with the class of 1878. From this time he was active in the Hewes & Phillips Iron Works and for many years was president and general manager.

Mr. Phillips was president of the New Jersey Foundrymen's Association, and a member of the American Society of Mechanical Engineers. He had a broad reputation as a steam and hydraulic engineer and was frequently called into consultation by eminent engineers in relation to large engineering projects. In addition to his business interests he was actively interested in all civic movements that had for their object the prosperity and upbuilding of his city and state, having been a member of the Newark Board of Trade, a member of the Essex Club, and at the time of his death he was quartermaster sergeant of the Essex Cavalry Troop, and had been major and inspector of small arms of the New Jersey Second Regiment of infantry.

Courtesy "The Newark Evening News."
FRANKLIN PHILLIPS

The funeral services, largely attended by friends, acquaintances and business associates of the deceased, were held at the Phillips homestead, Newark, on Feb. 12.

HENRY BRINTON

Henry Brinton, president of the H. Brinton Co., Philadelphia, died Jan. 30 at his home at Bala after a brief illness. He was born in 1848 at Christiana, Lancaster County, Penn., of a long line of Quaker ancestry descended from William Brinton who came to America in 1684. He received a thorough training as a machinist in the shops of I. Broomell & Sons, now the Christiana Machine Co. Later he spent about two and one-half years with Bement, Miles & Co. Colt's Armory drew Mr. Brinton to Hartford, Conn., where he worked for a time on the Baxter engine. His next work was on the Branson knitting machine at Bellefonte, Penn. The Branson Co. failed and Mr. Brinton went to the Lancaster Watch Co. at Lancaster, Penn., where he obtained experience in fine manufacturing methods. In 1888, Mr. Brinton started manufacturing knitting machines in the partnership of Brinton, Denney & Co. Five years later Mr. Denny sold his interests and the firm name became H. Brinton & Co. Mr. Brinton's wife, a daughter and two sons survive him.

POWER

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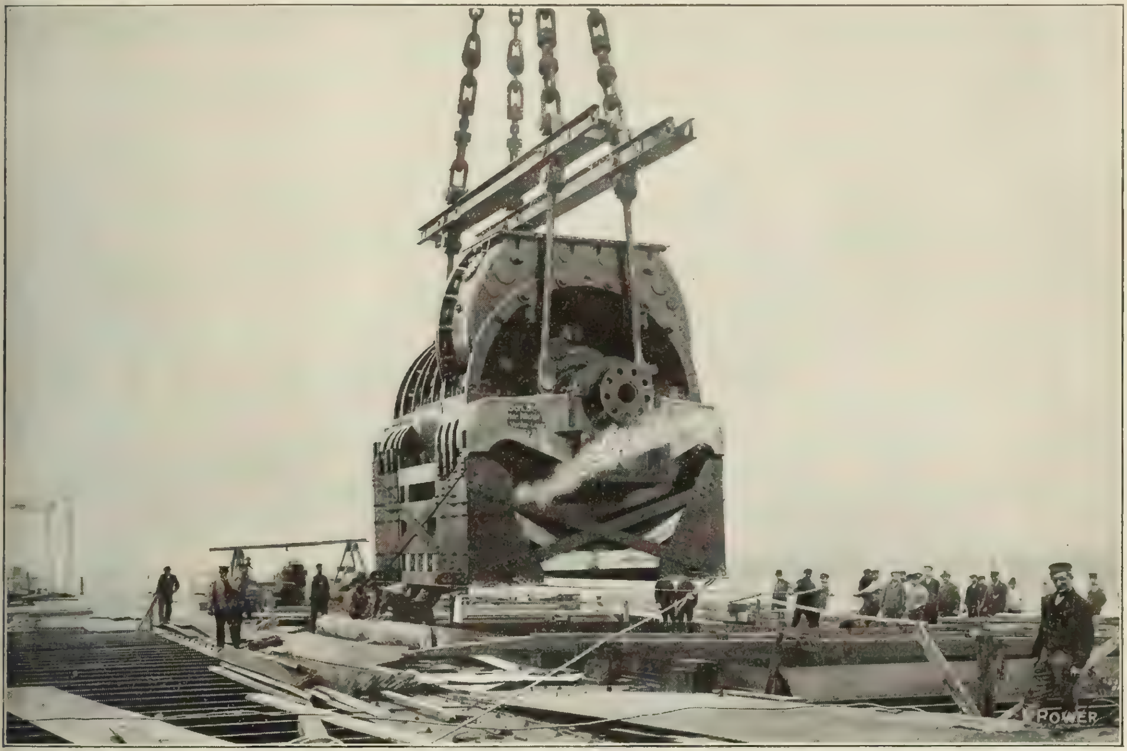


Take a Good Look at This Picture

Suppose the crane and tackle holding this great turbine should break. Those under it would be killed, those about it perhaps seriously injured. They feel sure it won't fall. They have confidence in the designer of the crane and tackle and trust the man who operates them.

More than this. They know the owners of the crane and equipment take every precaution to prevent such accidents by being critical in the selection of men and material.

The average citizen has only a vague conception of the potential danger in a boiler under high pressure. He has confidence in the skill and judgment of the attendant. In states and cities where boiler laws prevail this confidence is based on the knowledge that there is a systematic effort to be critical in the selection of men and material, just as with the handling of the turbine. In states where no such systematic efforts obtain, confidence is based on nothing more substantial than chance.

It is gratifying to know that each year, more communities act to eliminate the element of chance by creating laws that establish systematic inspection and promote safety.

The need for such laws is well known. Let every engineer unite with every other to make these laws uniform everywhere and promote universal confidence in themselves.

Vulcan Marine Steam Turbines

By Dr. Alfred Gradenwitz

SYNOPSIS—Briefly reviews the development of marine turbines by the builders of the "Imperator" and "Vaterland." Vulcan turbines are a combination of the Curtis-A. E. G. types and usually drive through hydraulic reduction gears. A total of 850,000 hp. is now in course of construction, 33,000 hp. being the largest unit.

⁂

The Vulcan Works at Stettin have had a paramount share in the development of marine turbines. In December, 1902, they undertook to build the small cruiser "Lubeck," the first turbine-driven cruiser of the German navy; the vessel was equipped with Parsons turbines. In the summer of 1904, the Vulcan works were awarded orders for the construction of the turbine steamer "Kaiser," of the Hamburg-American Line; this vessel was equipped with A. E. G. turbines. The construction of the "Stettin," the second turbine cruiser of the German navy, which was also equipped with Parsons turbines, was likewise entrusted to the Vulcan shipyards. These three vessels, with the exception of a small torpedo boat, were the first German turbine vessels. They proved most successful and the experience derived from their operation convinced the builders that steam turbines were to be received with favor as a means of ship propulsion. Further evidence of this was afforded by the rapid advance in the construction of the A. E. G. turbines for the cruiser "Mainz" of the German navy, which vessel, built in the Vulcan shipyards, exceeded, in her trials, performances stipulated by contracts.

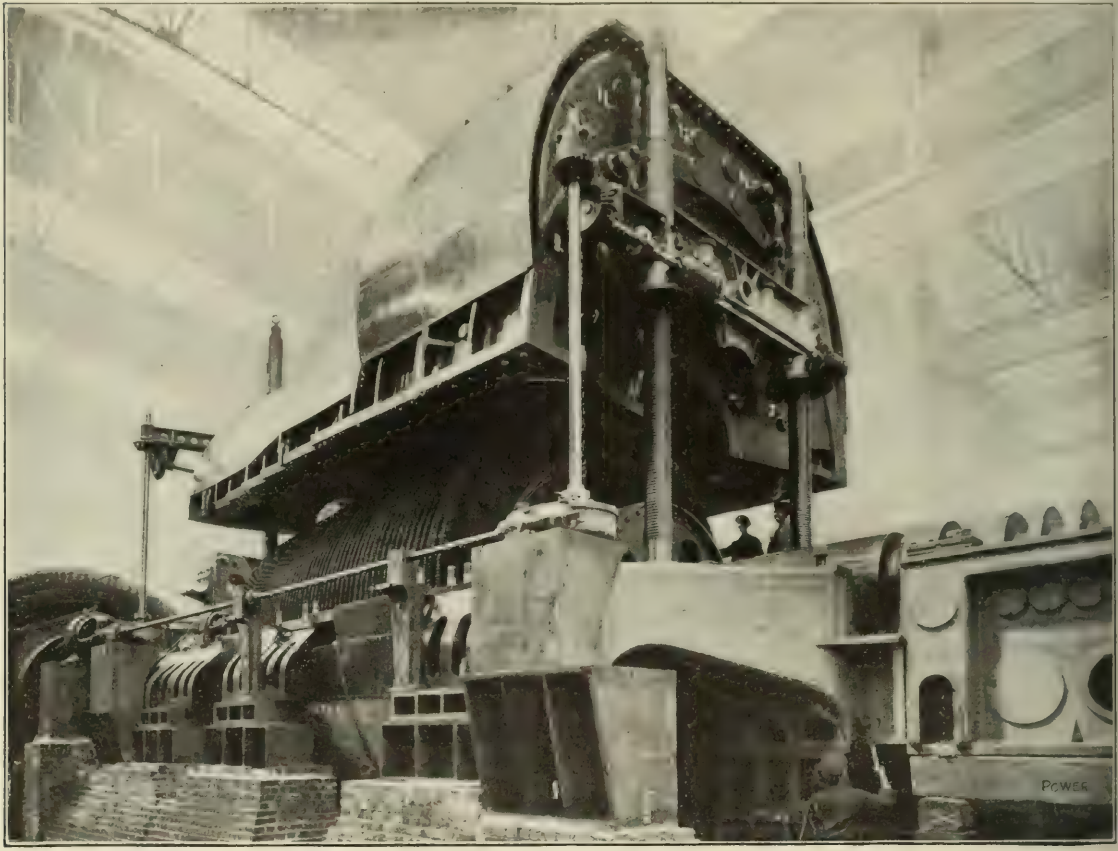


Fig. 1. The "Imperator's" 22,000-Horsepower, Low-Pressure Turbine

It was at this time that the management of the Vulcan Works resolved to engage in the construction of marine turbines on a large scale. To obtain a safe beginning for this new line of work, they concluded an agreement on a royalty basis with the Allgemeine Elektrizitäts-Gesellschaft, who had all the experience of the American Curtis concern at their disposal. Coöperation on this basis has after some years developed what is now known as the Curtis-A. E. G.-Vulcan turbine system. At the Stettin and the Hamburg works of the Vulcan Works 850,000 hp. in turbines is now in course of construction, the maximum individual output being 30,000 hp.

Fig. 1 shows the 22,000-hp., low-pressure turbine of the "Imperator." Note the motor-driven arrangement for raising the casing. Fig. 2 shows the low-pressure rotor for a turbine to be used aboard a large mercantile steamer. Note the blade lengths on the rotor, Fig. 2.

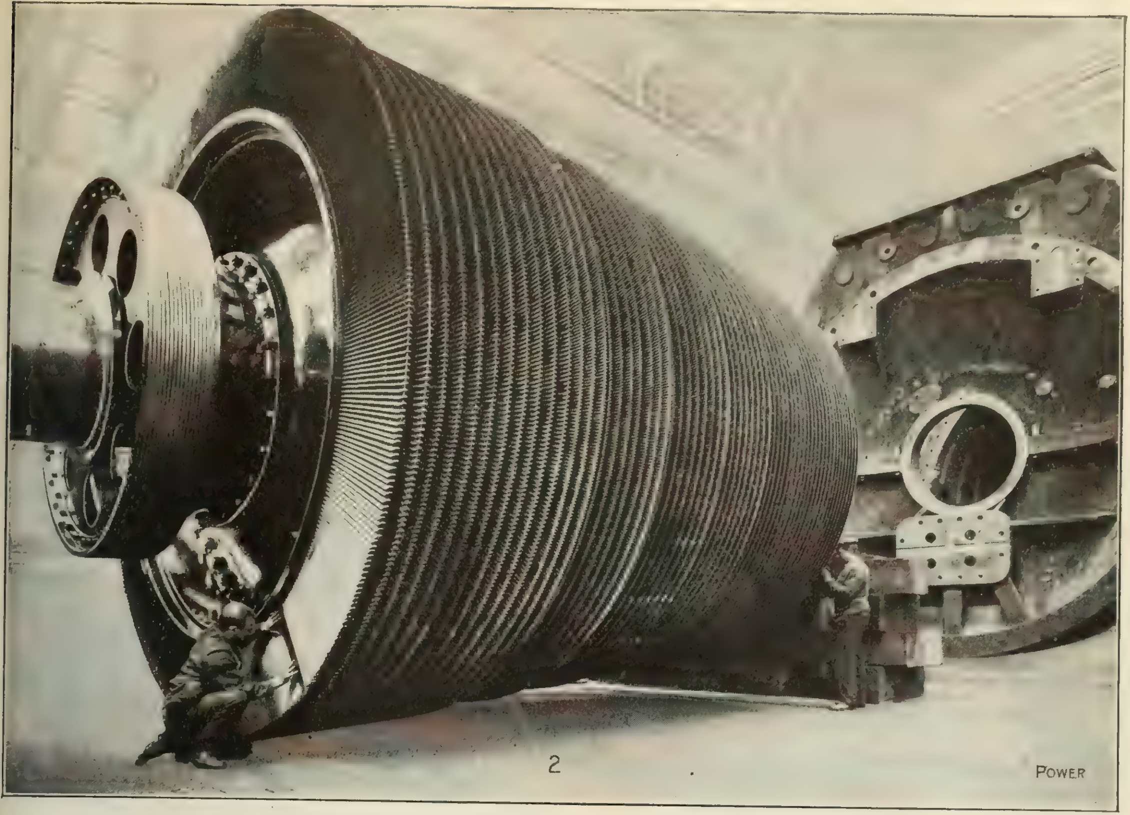


FIG. 2. ROTOR OF LOW-PRESSURE TURBINE FOR LARGE LINER; NOTE BLADE LENGTHS

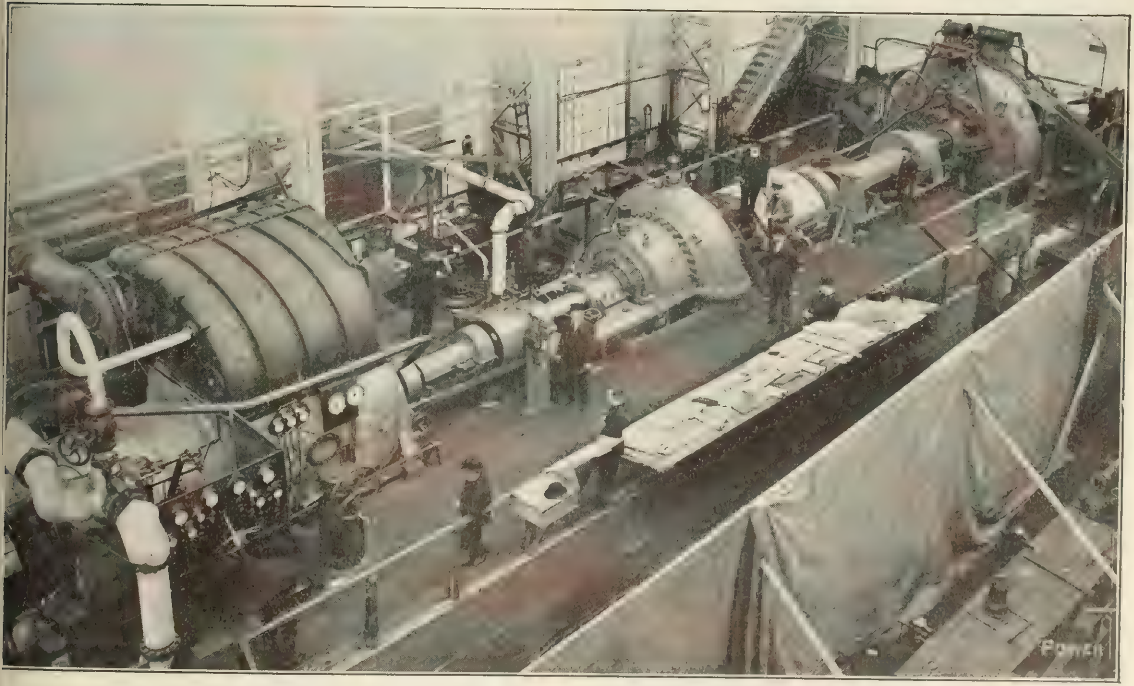


FIG. 3. TESTING TURBINE AND HYDRAULIC SPEED-REDUCTION GEAR

To confirm calculations, large units were frequently sacrificed for experimental purposes. Turbine parts, such as castings, some of very large dimensions, are put in a hydraulic press and the pressure increased until the steel castings crush, an engineer meanwhile observes, with the aid of instruments, the deflection of the castings.

Thorough care is exercised in choosing material. A large cast-steel turbine casting was deformed by Messrs. Haniel & Lueg under a hydraulic press, to demonstrate the quality of the steel supplied for turbine casings.

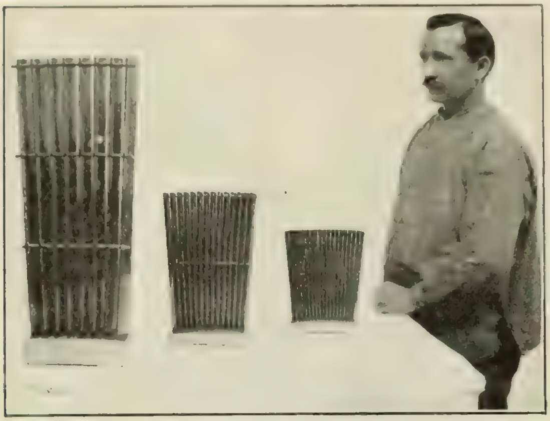


FIG. 4. BLADING OF LARGE LINER, SMALL LINER AND TORPEDO BOAT

The material intended for the blading is supplied in profile rods and is tested with special care, as slight defects in blade material may cause the most serious breakdowns at sea, when there are not adequate facilities for making proper repairs. Tests consist in gaging the form of cross-sections by means of the original patterns, having the profiled rods inspected by specially skilled workmen, ascertaining the breaking strength, tension, flexibility, surface hardness, etc.

Fig. 3 shows a 10,000-hp. turbine on the Hamburg work's test bed testing a Föttinger hydraulic speed-reducing gear.

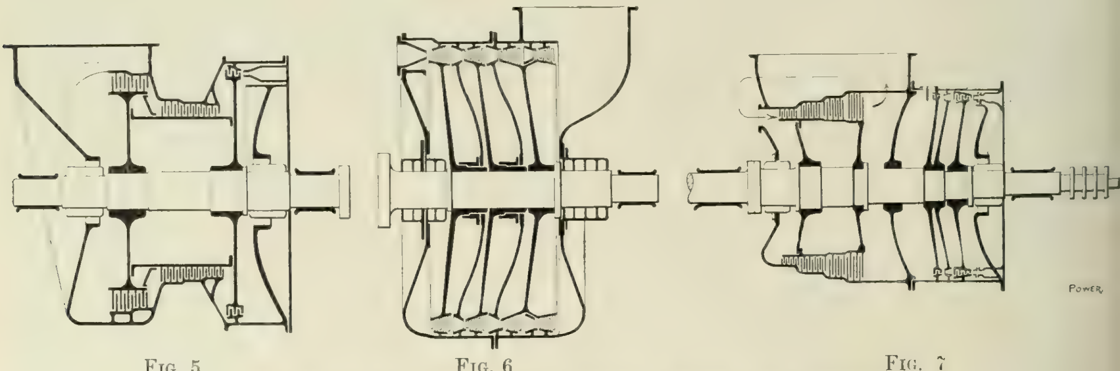


FIG. 5 FIG. 6 FIG. 7

SCHEMATIC ARRANGEMENT OF TURBINE WHEELS AND NOZZLES

The Vulcan ship turbines are designed on what is called a mixed system, that is to say, they are made up of one or more wheels bladed according to the action or reaction principle, or both. Fig. 4 shows some samples of low-pressure blades. The largest are reaction blades, and the smaller sets are action or impulse blades.

The turbines schematically represented in Figs. 5 to 7 are especially adapted for the driving of ship screws through hydraulic reduction gears, such as the Fottinger. Fig. 6 shows four low pressure Curtis stages mounted on a common rotor. Fig. 7 shows separated nozzle systems for small and great outputs, respectively, instead of cruising stages inserted into the turbine.

Several of the turbine designs as shown may, of course, be connected up in parallel or series, as is especially desirable in the case of very large units, which cannot well be arranged in a single casing, or with turbine equipment for multiple-screw ship.

Though the management of the Vulcan works is of the opinion that the use of turbines driving independently the various propeller shafts is the most rational means of ship propulsion, they will apply the Parsons series-connection principle, or, in fact, any other arrangement, to their own turbines when requested.

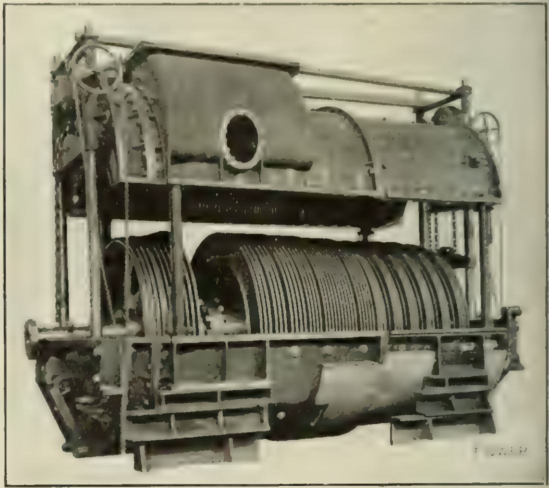


FIG. 8. TYPICAL TORPEDO BOAT TURBINE

The turbine shown in Fig. 8 is representative of those used on torpedo boats. The Russian "catcher" "Novick" is driven by Vulcan turbines and is capable of making 37.6 knots per hour. She is the fastest vessel of her kind.

Outdoor Substations

Commenting on outdoor substations, in a paper presented at the midwinter convention of the American Institute of Electrical Engineers, Alexander Macomber says:

"The success attained during the past few years justifies the expectation that out-door substations will occupy an important part in the development of transmission work. Complete outdoor installations up to a few hundred kilovolt-amperes have enabled service to be given to isolated customers and small communities which otherwise could not be served profitably directly off the main transmission lines. The simplicity of design and construction has meant a small investment and a minimum of operating troubles. The high-tension switching is usually limited to air-break types, instead of the costly oil switches, while lightning protection is afforded either by the electrolytic lightning arrester or the cruder horn type. Most such installations have been free from elaborate secondary control, that provided being, if any, of the simplest type, placed in weatherproof housings.

"The application of the outdoor substation to large capacity installations, particularly where the secondary control is split up into various circuits with more or less auxiliary apparatus involves larger problems. With substations of this character, involving attendance, it is necessary to provide a suitable building designed for at least part of the installation. What part of the high-tension apparatus may properly be installed out of doors depends largely on the saving thereby effected. The actual outdoor apparatus must be provided for separately, and a combination of the indoor and outdoor substation will in many cases prove most advantageous. In some cases it is feasible to place the whole outfit out of doors, including the low-tension control equipment, provided the latter is not extensive, but in most cases it is questionable whether the operating features will permit this extreme. In cases where attendance is required it is certainly advisable to install the secondary equipment indoors.

Protective Equipment

"The most important protective apparatus affected by outdoor installation is the electrolytic lightning arrester. Heretofore, this equipment has been protected by housing, but the development of low-temperature electrolyte, and other details of design, makes it possible to place the apparatus out of doors, even under the most severe climatic conditions. The winter season, when the severest temperatures are encountered, is, as a rule, free from lightning disturbances, although it is important to secure continuous service of such protective devices on account of surges occurring on the lines. It is as much the function of the arrester to absorb these disturbances as to avert the direct effects of lightning.

Transformers

"The principal difficulty met with in connection with the transformers is the climatic changes. In general the outdoor transformer is similar to the indoor type, except that the cover and leads are designed to shed moisture and provide the necessary high factors of safety.

"Both self-cooled and water-cooled transformers are applicable to this service. With the former, grades of oil suited to the conditions are necessary. Usually the electrical load will keep the oil sufficiently warm, but precautions must be taken to prevent condensation of moisture. Sometimes this is accomplished by installing small heating coils in the upper part of the transformers. Freezing of the oil itself may be guarded against in idle units or under severe conditions, by external heating devices under the casings. Little trouble is experienced, however, as ordinary oil will not freeze at a temperature above —15 deg. C.

"The use of water-cooled transformers involves similar precautions against moisture, with the addition of protection to the water-circulating system, although the water due to its circulation probably would not freeze except under very severe conditions, provided the external connections are properly protected.

"There has been little experience with air-cooled transformers out of doors. It would seem that there might be a field for them as they do not offer the difficulties in providing climatic protection that are encountered with other types, provided moisture is kept out.

Control Apparatus

"Control apparatus, such as switches, circuit-breakers, etc., have met the severe conditions imposed and outdoor switches of high voltage are operating satisfactorily in severe sleet and snow storms."

Civil and Military Engineering at the Panama-Pacific International Exposition

Since the nations of the world will assemble war craft at Hampton Roads to proceed in a grand national pageant to the Panama-Pacific International Exposition in 1915, it is easy to understand the interest that is being taken in the display in the Palace of Liberal Arts, of the methods, processes and other phenomena of military and civil engineering, which is scheduled under group 40 in the department of liberal arts, the chief of which is Theodore Hardee.

Methods used in earthworks, in the construction of canals, railroads, levees and embankments will be prominent features of the exhibit in this connection, and municipal authorities, who promise to attend the exposition in great numbers, will be interested in the display of equipments for city sanitation. Methods employed in storing and distributing water will be given adequate representation, and for the military expert there will be provided full exhibits of various methods of defensive construction and engineering material employed in the operation of an army.

The contractor, builder, property owner and scientist will be interested in the exhibit of the methods employed in the testing of structural materials, the equipments and methods for the construction and maintenance of city, suburban and country roads. The methods and equipment for preparing foundations, including piles, pile-drivers, screw piles, caissons, wire trams, etc., will be shown in great variety.

Roadmaking is scheduled in group 41 of the exposition's classification of industries, and is embraced with the displays of inland navigation, the improvement of rivers, construction of canals, ship railways, reservoirs, pile sinkers, dredgers, sea port improvements, piers, docks, bridges, viaducts, maritime canals, protection against flooding by rivers or by the sea, elevated railways, tunnels and statistics, maps and other publications relative to public works and engineering societies.

* * *

Western Canada Power Co. to Increase Plant—The Western Canada Power Co., Vancouver, intends to add two 13,000-hp. hydro-electric generating units to its present plant. One of the new turbines will be installed next spring and the other early in 1915. The present plant of two units is capable of generating more than 25,000 hp. The additional plant and equipment of the new unit, including installation, will involve an expenditure of $500,000.

Gas-Producer Operation

By E. G. Moon

Among the important requirements of a producer gas for power purposes are that dust, soot, and tarry matter be removed, and that the temperature be lowered before the gas is delivered to the engine. The advantage of lowering the temperature is that the density of the gas is increased, so that a given volume can develop more power because it contains more heat units.

Installation

In setting up the producer care should be taken to facilitate the proper handling by raising it to such a level as will aid in cleaning and removing ashes and clinkers. If the producer is placed too close to the side walls, the operator will be hampered. Moreover, it must be in proper alignment and placed so as to avoid the use of unnecessary piping and fittings. Provision should be made for proper drainage from the scrubber, as the cleaning water is likely to gather considerable sulphur and tarry matter, which sometimes gives trouble in clogging and causes deterioration of the piping. After the producer has been set up on its foundation and aligned, the grates are put in place, and then the shell is lined with a good grade of firebrick.

The firebrick are usually of special shape, according to the construction of the producer. They should be carefully selected and any broken or cracked bricks discarded. It is well to order a few extra bricks, as more or less are broken in transit. Before placing the lining in the shell a template, as illustrated, should be made and laid out on the floor. In making this template allowance is made for an annular opening of at least 1 in. between the outside of the lining and the inside of the shell; this space is for insulation purposes. In fitting the brick to the template it is important that they fit each other closely, so as to not leave any openings or crevices between the brick greater than 1/8 in.

After the brick have been fitted to conform to the template, the laying of the lining may proceed. The mortar is made of a good grade of fireclay and water thoroughly mixed to the consistency of cement mortar. In placing the lining care must be exercised to make the joints smooth, as any irregularities or projections cause clinkers to adhere. As the operator uses the brick wall as a guide for the poking bar in scraping down the fine ash and clinker, the bar is apt to catch on projections and damage the lining.

After the fifth or sixth course of brick has been laid, the space between the lining and the shell should be filled in with a cement of asbestos and fireclay. This serves as a bottom for the insulation material, which usually consists of ordinary sand, although in some cases asbestos is used. The cement should be thoroughly tamped in to a depth of 12 or 14 in.; this prevents the sand from running out at the bottom. Further courses of firebrick are then laid, more sand is poured in and lightly tamped until within 3 or 4 in. from the top of the lining, the remaining space being filled in with asbestos and fireclay mortar.

If the producer is equipped with sight holes, corresponding openings in the brickwork must be provided. Pieces of iron pipe should be inserted through the sight holes, and the space around the pipe should be packed with asbestos and fireclay cement to prevent the sand from running out.

The lining having been completed, it should be looked over for cracks, and when found they should be filled in with a cement of asbestos and fireclay mixed to the consistency of putty. If the ordinary mixture of fireclay and water is used it will crumble and fall away on coming in contact with the fire.

The producer should now be cleaned out, after which it is ready for the cover to be bolted or riveted on. Next, the charging hopper and poke-hole covers are connected. Some producers have a bell-shaped casting to collect the gas from the center of the fuel bed which, of course, must be connected before placing the hopper in position. Where a mechanically operated poking bar is attached to a stationary connection inside the producer it must also be connected before putting the hopper in place.

Some producers have water jackets or superimposed vaporizers to supply the incoming air with vapor on its way to the fuel bed. Others use a small boiler between the producer and the scrubber; where boilers are already installed steam may be supplied from them. Also, in several installations heaters are connected in the exhaust pipe of the gas engine, the jacket water passing through to the vaporizer. The steam supply is controlled by the amount of water allowed to feed to the vaporizer.

Again, some installations use the exhaust gases from the engine for controlling the temperature of the fire in the producer.

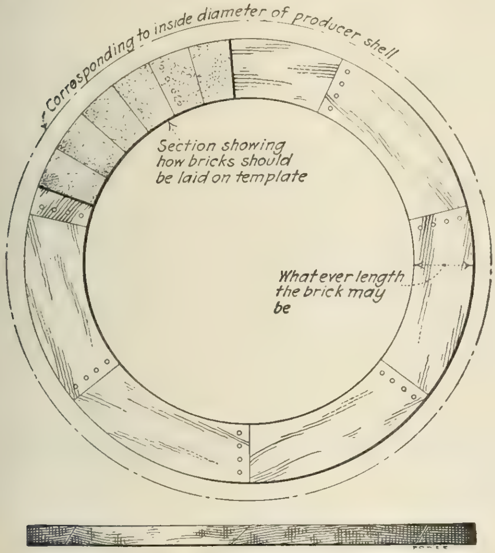
Cleaning and Cooling Gas

There are many types of scrubbers for cleaning and cooling the gas before it is delivered to the engine. Some consist of cast-iron shells sealed at the bottom and filled with wood slats, broken brick, charcoal, coke, or special cast-iron baffles. At the top of these scrubbers is attached a connection for cold water which flows down in a spray through the shell and comes in contact with the outgoing gases, thereby cleaning and cooling them. The water passes down into the water seal, then to the sewer or other outlet. The amount of water is so controlled as to allow enough to cool the gas to as nearly the surrounding temperature as possible. There are also mechanically operated scrubbers built to impart a centrifugal motion to the gases and at the same time inject cold water.

Some producers have a wet and a dry scrubber, the latter for further removing any tarry matter or dust that the wet scrubber fails to remove, but the principal reason for the dry scrubber is to separate any undue moisture that may be in the gas after leaving the wet scrubber. The many designs of dry scrubber consist essentially of a cylindrical shell filled with wood slats or excelsior and set in a water seal. Instead of a dry scrubber some installations employ a cylinder attached to the gas line between the wet scrubber and the engine; this is called a separator. The outlet from the gas line has a running nipple about one-third the length of the separator connected at the top and the gas outlet is also so connected. If the gases contain any moisture, it will settle to the bottom of the separator and then pass out through a water seal.

Producers are generally provided with a purge pipe leading to the atmosphere. This pipe is to be opened when the apparatus is shut down, and closed when it is running. Some installations have fan blowers to create a draft when starting the producer; others employ natural draft through the purge pipe, while still others use a steam blower for this purpose. The latter method is possible where boilers are at hand. Still another arrangement consists of a special blower working on an air blast from the engine's starting tanks.

In connecting up the piping, fittings and various auxiliaries, precautions should be taken to see that they are thoroughly clean and free from scale on the inside.


Corresponding to inside diameter of producer shell
Section showing how bricks should be laid on template
Whatever length the brick may be

Template for Producer Lining

When connecting the scrubbers to the producer a very high heat-resisting packing should be used. All bolts, nuts and screwed pipe fittings should be coated with graphite and a good grade of oil, to facilitate taking them apart readily when repairs are necessary.

Operation

The producer and its auxiliaries having been installed and connected, the installation is made ready for service. All places where water seals are necessary should be filled with water; the gas valve leading to the engine should be closed and the valve on the purge pipe open. See that all the cleaning and ashpit doors are open; in some types the air inlet to the producer is closed and a blower is attached. Before building the fire, spread enough loose ashes over the grate and bottom of the producer to cover all metal work, then start a wood or soft-coal fire which will produce smoke and observe whether the joints are tight. If no leaks are noted, charge the producer with a small amount of coal and keep up a slow fire for several days to dry out the lining thoroughly; otherwise cracks are likely to occur. After the producer has been dried out it may be charged with coal to the required depth.

It is important that the fire burn evenly before filling the producer; then watch for any dead spots, as they form air holes and give trouble by permitting the air to pass through the fuel uncombined and thus dilute the gas. A try-cock or pilot light is usually connected to the outlet of the producer for ascertaining the quality of the gas. The trycock should be covered with a piece of wire gauze to prevent the flame from flashing back. A second purge pipe is connected to the gas line near the engine for freeing the line of air, as all the air should be expelled from the system before any flame comes near the outlet, otherwise an explosion may result. As soon as the gas burns freely at the pilot, the producer is ready for service.

The vent pipe at the engine should be closed, the air inlet at the bottom of the vaporizer opened, as well as that to the producer, and the purge pipe of the producer closed. Then turn on the water to the scrubber and the vaporizer, and as soon as the engine is started close the ashpit and cleaning doors.

The operator must not become discouraged if the producer does not at first respond according to his expectations; it may take several days before the proper adjustments are made to meet the conditions. One must become familiar with the required mixture of gas and air at the entrance, but this can only be determined by experience as different engines require different mixtures. Assuming that the engine is in good condition and properly adjusted, all that it needs is good gas; then the operator must turn his attention to the producer. He must watch the vaporizer and adjust it according to the instructions of the builder. The scrubber must also be watched to see if the gas is being delivered cold; if not, sufficient cold water should be turned in to cool the gas.

While the instructions may recommend poking the fire at certain intervals, it may be necessary to do this oftener, which will indicate that the producer is too small to carry the load. Some instructions say to clean the grate every 24 hr. and the ashpit once every other day, yet the writer knows of cases where the grate must be cleaned two or three times and the ashpit once or twice during the 24-hr. period.

Conditions in many plants cause a variance of operation as regards poking and cleaning; but conditions must be ascertained and judged by the operator himself.

It is essential to poke down the fine ash which accumulates on the walls; it is likely to fuse and form clinkers. When these form, the efficiency of the producer is greatly impaired as some of the incoming air will get by the clinker and materially weaken the gas; also, the poking down is hampered. Before poking down, the operator should remove the ashes from the edge of the grate so as to make room for those that are to be poked down from the walls of the lining. In cleaning the ashpit the door should not be open too long, as it may allow too much air to be drawn through the fuel bed. In taking out the ashes, remove just as much as will not disturb the clean portion of the fuel bed. This operation being disposed of, it is well to wait a few minutes before poking. Some producers are equipped with shaking grates.

In poking, a straight bar is used. The operator opens one poke hole at a time and bars down close to the wall of the producer, in a scraping fashion, to remove all fine ash from the lining, keeping the poking bar as close to the lining as possible so as to scrape it clean. He will soon be able by feeling to distinguish the difference between the soft ash and the hard walls of the lining. Poking must be done quickly in some types of producers, as air is apt to be drawn in and weaken the gas. After the poking bar is removed the poke holes should be immediately closed and the operator proceed to the next one. When this is completed the grates may be cleaned again; that is, the edge of the grate. Of course, the second cleaning depends upon the condition of the fire. In cleaning the grate, be careful not to work the fire down too low as burning and warping of the grate and the metal work around it may result. The operator will learn by experience how often it will be necessary to flash the fire.

When seeking the depth of the fuel bed through the sight holes, precaution should be taken not to place the eye too near the hole as a flash of flame may cause a severe burn; a piece of glass or sheet mica against the hole will prevent this. In shutting down the plant, assuming the engine to be already shut down, open an ashpit door slightly, shut off the air inlets to the producer, the main valve on the gas line to the scrubber and the water supply to the scrubber; then open the purge valve just enough to maintain a proper draft during the standby period, while the producer is shut down. It is well to remove whatever thermometers that may be attached.

After the producer has been in operation some months trouble may be had in getting good gas. In such a case, see if the water is of the proper height in all water seals; look for clinkers, and if any are found regulate the vaporizer. If the producer is equipped with a thermostat this may be found corroded or perhaps the baffles or filling of the scrubber may need cleaning or renewing. Moreover, there may be leaks between the scrubber and the producer or leaks in the gas line itself, or possibly air holes in the fuel bed. If the producer is equipped with a tubular boiler, and the temperature of the water cannot be raised, the tubes may be covered with scales. If gas is not being delivered cold, the spray pipes and the scrubber may be corroded, or broken or split, thus causing the water to flow down the side of the shell, or the filling may need cleaning or renewing. If a centrifugal scrubber is employed, the vanes should be examined for deposits of tarry matter.

If the producer has been heavily taxed, the brick lining may become burned. All burned brick should be thrown away. Those not entirely burned out may be used for the upper courses and new brick supplied for the lower ones, but it is cheaper eventually to put in an entirely new lining.

The writer knows of several producer-gas plants now out of service, owing to abuse and overloading, brought about by employing inexperienced operators. In most of these cases the apparatus has been condemned and given up through no fault of its own. In many plants it is difficult to obtain skilled labor, and foreign labor is employed. If so, it is well to have a set of instructions got out in the language of the laborers and placed conspicuously in the producer room.

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Spark-Gap Gage for High-Potential Testing

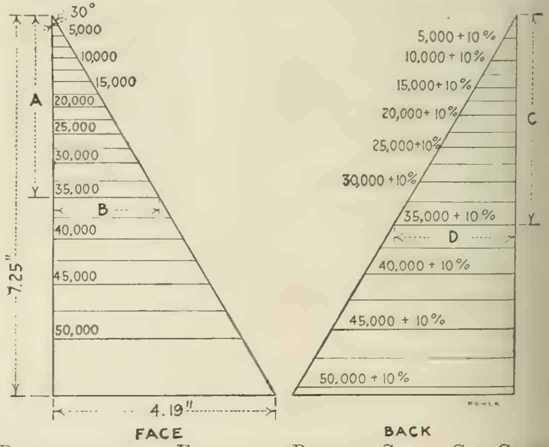
By H. M. Nichols

The usual practice when making high-potential tests is to have a spark gap in multiple with the testing circuit. The spark gap is usually set for a voltage 10 per cent. greater than the test voltage, and the voltmeter readings are depended upon for determining when the full voltage is obtained, the spark gap simply serving as an auxiliary protection. If greater accuracy is desired, the spark gap is first set for the exact test voltage and then the potential is gradually raised until the gap breaks down, notice being taken of the voltmeter readings just before this happens.

New needle points are next inserted and the gap is set for a 10 per cent. increase in voltage. The test is then made, the voltage being determined by setting the voltmeter to the same reading as was obtained just before the gap broke on the check test.

The usual way of setting the spark gap is to look up the number of inches, corresponding to the desired voltage, in a table on sparking distances, and then measure the distance between the two points. Where a large number of settings are made, as is the case in the commercial testing departments of large manufacturing concerns, the operation consumes considerable time. To save time and to insure greater accuracy, the gage shown in the sketch was devised.

While this gage was intended primarily for use in factory testing, it should prove of value to anyone who has much outside testing to do, as, for instance, the repair department of a large central station. An advantage of the device, other than the labor-saving feature, is that there is little chance for error in setting the gap, and



Reproduction of Front and Back of Spark-Gap Gage consequently little danger of damage to the apparatus from applying excessive voltage.

TABLE OF DIMENSIONS FOR SPARK-GAP GAGE

	Front			Back	
Voltage	A, In.	B, In.	Voltage + 10%	C, In.	D, In.
2,500	0.19	0.112	2,500	0.22	0.124
5,000	0.39	0.225	5,000	0.43	0.25
7,500	0.61	0.35	7,500	0.66	0.38
10,000	0.81	0.47	10,000	0.88	0.51
12,500	1.04	0.60	12,500	1.14	0.66
15,000	1.25	0.72	15,000	1.40	0.81
17,500	1.49	0.86	17,500	1.65	0.95
20,000	1.73	1.00	20,000	1.92	1.11
22,500	1.98	1.14	22,500	2.24	1.29
25,000	2.25	1.30	25,000	2.53	1.46
27,500	2.52	1.46	27,500	2.84	1.64
30,000	2.81	1.62	30,000	3.18	1.84
32,500	3.14	1.81	32,500	3.58	2.07
35,000	3.46	2.00	35,000	4.01	2.32
37,500	3.85	2.22	37,500	4.45	2.57
40,000	4.25	2.45	40,000	4.94	2.85
42,500	4.67	2.70	42,500	5.47	3.16
45,000	5.11	2.95	45,000	6.03	3.49
47,500	5.64	3.25	47,500	6.58	3.80
50,000	6.15	3.55	50,000	7.10	4.10

The gage is made from a piece of flat steel, about 1/8 in. thick, ground to the dimensions shown, care being taken to have the edges straight and true, and the angle exactly 30 deg. One side of the gage is laid off for even voltages, and the opposite side for voltages 10 per cent. in excess of these voltages. The table gives the dimensions *A* to be used in laying off the lines on the gage corresponding to the various voltages. The dimensions *C* are used for laying off the back of the gage; while the dimensions *B* and *D* can be used to check the work of laying off the lines and to determine the accuracy of the gage.

The lines should be straight and true and cut deeply into the steel, so as to be easily seen. The figures should be stamped plainly and especially the 10 per cent. part in order to avoid the danger of some careless tester using the divisions on the back of the gage for those on its face.

A New Blowing Engine

Prior to the introduction of the gas engine, it was the general blowing-engine practice to limit the piston speed to 600 ft. per min., although cases were known where speeds of 800 ft. were employed.

To furnish the requisite amount of air for the blast furnace at such speeds as this required a ponderous and costly engine, and it was found desirable to increase the piston speed to 800 or 1000 ft. per min. to keep down the size of the engine. As a consequence, it was necessary to adopt some new design of blowing tub with much larger valve openings than formerly, so that the cylinder at the increased speed would be properly filled with air. To meet these requirements a new type of blowing engine has been designed by R. C. Holman. Its construction is shown in the accompanying illustrations.

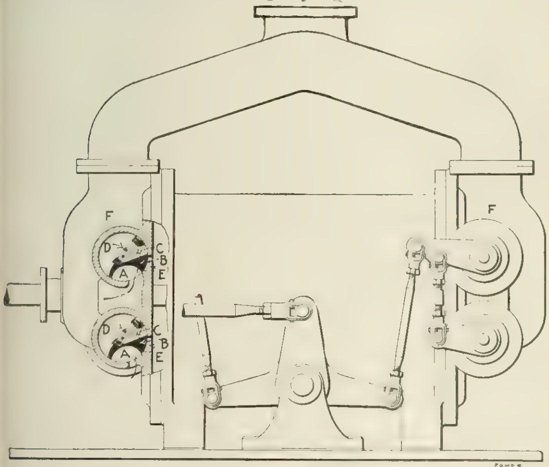


Fig. 1. Inlet Valve-Gear Side, Horizontal Blowing Cylinder

It is claimed by the designer that a blowing engine of the type shown can be built having inlet ports 25 per cent. of the area of the cylinder, and outlet ports 15 per cent. of the area of the cylinder, with a volumetric clearance of not over 1 per cent.

To remove both inlet and outlet valves from the cylinder it is necessary to take off the bonnet and withdraw the valve exactly as any Corliss valve is taken out. This valve contains all of the inaccessible parts of the air-distributing mechanism and will fit in any of the valve ports in the cylinder, provided that the ports are all bored alike. One complete valve in reserve then will provide a full set of repairs for all of the valves.

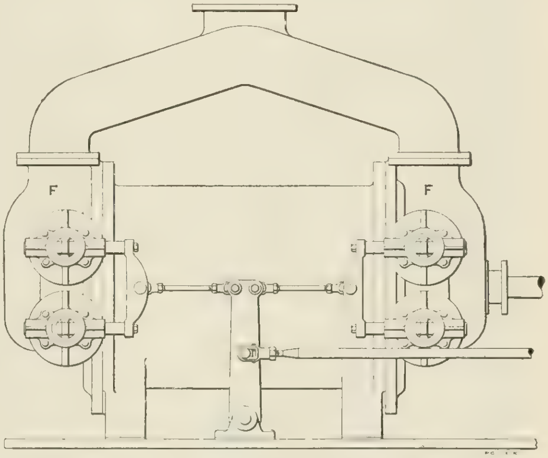


Fig. 2. Outlet Valve-Gear Side of Cylinder

In the past, the use of flat gridiron and Corliss valves for compressors and blowing engines has not been attended with the best results, on account of the difficulty in properly lubricating the inlet valves. There is always enough oil pumped into the cylinder to properly lubricate the outlet valve, as the air leaving the cylinder is laden with oil. In the Holman machine the oil is pumped directly on the surface of the inlet valve at the edge of the port.

Fig. 1 shows the inlet valve-gear side of a horizontal blowing cylinder, and Fig. 2 the outlet valve-gear side. Fig. 3 is a section on the vertical center line through the cylinder and shows the valves in their proper relative position for the piston as shown. Fig. 4 is a section through the center of the valve and shows the outlet gridiron valve at the back of the inlet Corliss valve. Fig. 5 is a side view of a steam-driven blowing engine with the air cylinders behind the steam cylinder.

As will be apparent, the cuts show a steam-driven unit. The power is taken directly from the crankshaft and pin, while with a gas engine the valves are driven by eccentrics mounted on a layshaft, similar to the manner in which the inlet and outlet valves on the gas cylinder are driven.

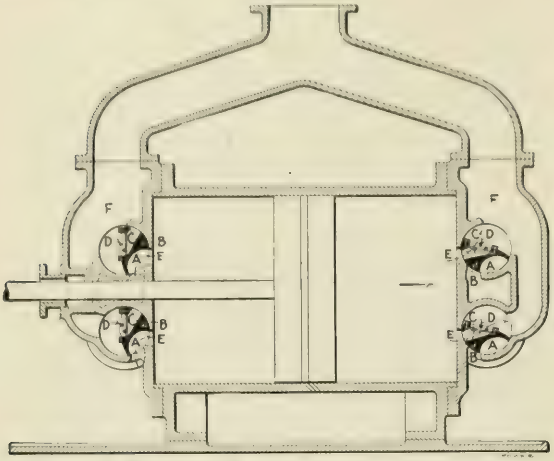


Fig. 3. Vertical Section through Cylinder

Referring to Figs. 1, 3 and 4, A represents the inlet port through the inlet Corliss valve *B*, and *C* is the outlet port. The ports *E* in the cylinder head are alternately inlet and outlet ports, depending whether the piston is approaching or receding from the cylinder head. Each cylinder head contains two valves exactly alike, which are connected and work in unison. It is because both ports are used as inlet or outlet, as the requirements may be, that it is possible to secure such large openings with so small volumetric clearance.

The circular Corliss valve *B* of the sections shown in Figs. 1, 3 and 4 is given the proper oscillating motion by the valve-gear shown in Figs. 1 and 2, which is driven from the crankshaft in the case of a steam engine and from the layshaft of a gas engine. It is provided with the inlet and outlet passages referred to, and is fitted to a tee-headed valve stem *M* in the ordinary manner.

At one end of the outlet passage *C* through the valve *B* are cast a series of bars making gridiron openings through the valve, as in Fig. 4. The valve *B* is machined at this point to form a seat for the gridiron valve *D*, the openings through which correspond to the gridiron openings in the valve *B*. Rectangular ports *E* are cast in the cylinder head and act as inlet ports to the cylinder when the valves are in the position shown at the left of Fig. 3, and as outlet ports from the cylinder when the valves are in the position shown at the right of Fig. 3. At the center of the cylinder *F* is a passage connecting the discharge from each valve with the blast pipe. Fig. 4 is a horizontal section through *F*, and Fig. 1 is a section at one side of *F*. In Fig. 4, *G* are thrustwashers with a spring to hold the valve *B* from slapping back and forth with the movement of the gridiron valve *D*. In practice, however, these washers are only needed in starting, as the unbalanced pressure of the valve stem *M* is more than the friction of the gridiron valve *D*. A cam bar *H* gives motion to the crosshead *I*, which in turn operates the gridiron valve *D*, the thrustwashers *K* being used to transmit motion and at the same time allow the gridiron valve to oscillate with the Corliss valve *B*. The crosshead *I* does not oscillate, but has a sliding motion in the bonnet *L* from the cam bar *H*. At high rotative speeds it has been found preferable to substitute a link-driven mechanism for the cam on account of the liability of noise if the cams are not carefully fitted.

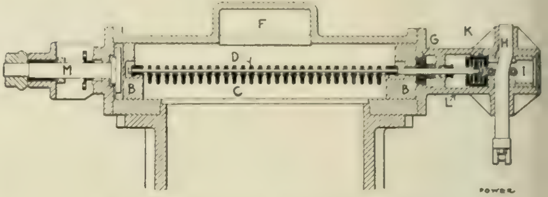


Fig. 4. Section through Valve

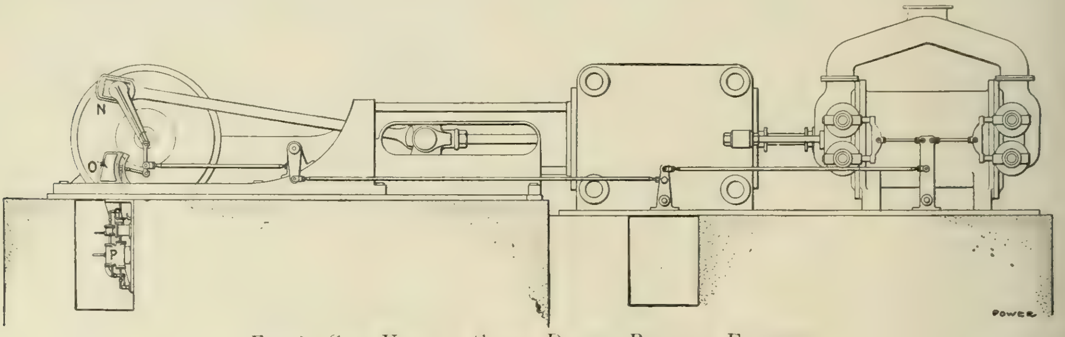


Fig. 5. Side View of Steam-Driven Blowing Engine

The outlet driven mechanism is shown in Fig. 5, and consists of an arm keyed to the crankpin of the engine and set so that the pin at its end describes a circle. A quadrant *O* is fitted to the engine frame. In this quadrant slides a block to which is attached the link. The position of this block is governed by the piston in the relay oil cylinder *P*. The pressures in the blast pipe and blowing cylinder act upon a pilot valve which allows oil pressure to enter the actuating cylinder and so place the block in the quadrant that the outlet valve will open only when the pressure in the blowing cylinder is equal to that in the blast pipe. For example, if for some reason or other the blast pressure should suddenly drop, the pilot valve would immediately move, due to the difference in pressure between that to which the air was being compressed and the blast pressure. This movement would allow oil pressure back of the actuating piston and change the position of the block in quadrant *O* to such a point that the outlet valve *D* would open when the compressed air in the cylinder would equal in pressure that in the blast pipe.

The actions of all the valves are positive. The time of opening and closing the inlet passage to the cylinder is determined by the Corliss valve *B* and is fixed; the inlet is opened when passage *A* is in communication with port *E*. The time of closing the discharge is determined by the Corliss valve *B* and is fixed. The time of opening the discharge is controlled by the discharge valve *D* and depends upon the pressure of air in the cylinder with relation to that in the blast pipe. There is never any possibility of the inlet and outlet ports being opened at the same time and the gas coming back from the blast furnace.

* * *

Boiler Explosion at Ottawa

A disastrous explosion of a return-tubular boiler occurred in the Fat Stock Building, at Howick Hall, Ottawa, Can., at 8 a.m., Jan. 21, killing three and injuring six. A cattle show was being held in the building.

The boiler, which was built in 1906 for a working pressure of 70 lb., was 60 in. by 14 ft. and had one girth seam only. The shell was $\frac{5}{16}$ in. thick and the heads $\frac{3}{8}$ in. thick; the boiler had 82 three-inch tubes. The girth seam was single riveted with $1\frac{1}{16}$-in. rivets spaced at 2-in. centers. The longitudinal lap seam, when new, had a strength of 70 per cent. of the solid plate. The manhole had a cast-iron ring, which, at first, was thought the cause of the accident. The ring was split in two, but the rivets held. Most of the girth-seam rivets were sheared, although for a short distance the plate gave way.

There is considerable speculation as to the cause of the accident, but evidence produced at the inquest showed that the safety valve (of the ball-and-lever type) was not working properly, and that the boiler stop valve was only open $\frac{1}{16}$ of an inch; also that the pressure was on top of the disk.

Four different engineers have handled the boiler since it was installed, and they all appear to have set the safety valve to suit themselves. To remedy this state of thrustwashers *K* being used to transmit motion and at the

Boiler Explosion at Ottawa

sealed pop valves, or that the inspector stamp on the boiler the allowable pressure.

Some idea of the force of the explosion can be gathered from the fact that a horse weighing over a to was blown through the roof and landed 90 yards awa The total damage amounts to over $100,000.

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Power-Plant Safety Devices

Various means have been adopted by different companies to guard against the accidental opening of the stop valve when a boiler is out of commission, and more particularly when there is anyone working in the boiler.

Perhaps one of the most effective means is that illustrated in Fig. 1, where *A* is a hinged metal case, painted red, which is slipped over the valve wheel and locked; *B* is a metal tag painted red with white letters. All the boilers are numbered both on the front and on the rear, and the valve is also numbered correspondingly with a metal plate, as shown at *C*. This avoids any possible confusion in operating or in locking the wrong valve. Th right-hand view shows the casing locked over the valv wheel.

The position of stoker drive chains and sprocket whee is frequently a menace to the men in the boiler roo In Fig. 4 is shown a method of safeguarding them, wher the chain and the upper sprocket are encased by th plate shield *A* and the cast-iron shield *B*. The chain i oiled through the door *C*.

In Fig. 5 is shown the method of placing guards on 1600-hp. motor rotor. The guards have a metal fram

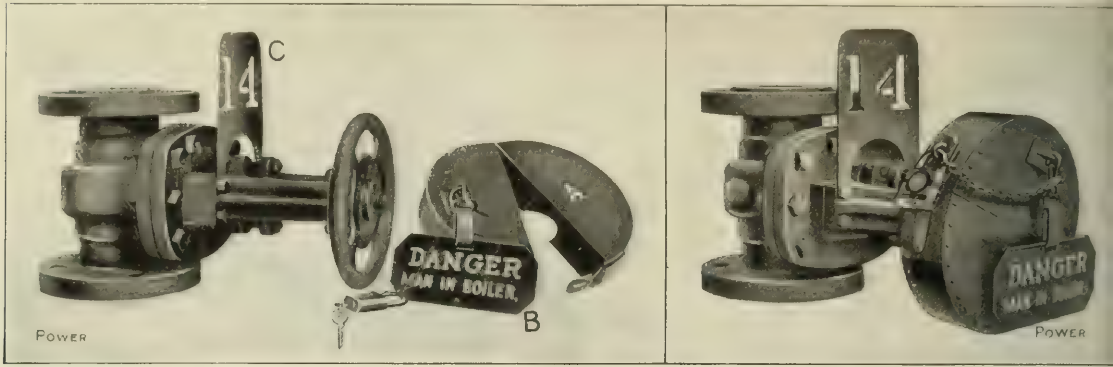

Fig. 1. Open and Closed Position of Valve-Wheel Locking Device

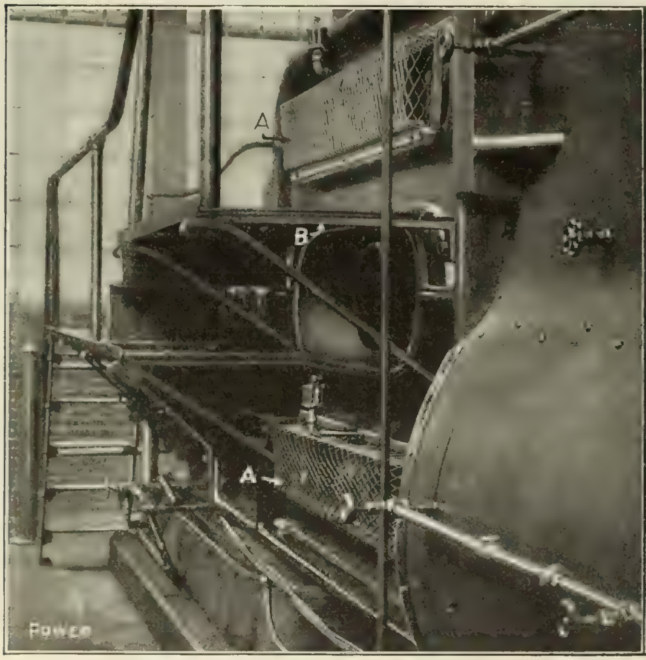

Fig. 2. Guards for Pump Crossheads

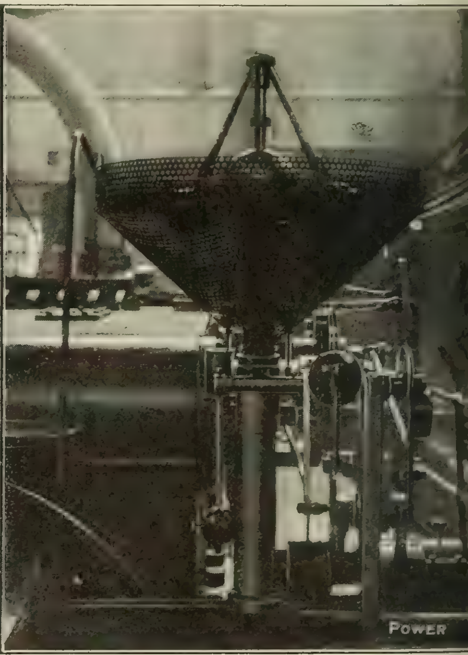

Fig. 3. Perforated Governor Guard

which wire netting is attached. The shields are hinged the longest side to a metal upright, secured to the oor at one end and bolted to the motor frame at the her.

A method of guarding the flywheel governor of a roll-ng-mill engine is shown in Fig. 6. The guard is secured a metal cross-piece supported by the governor frame, nd the shield is made of sheet iron. Another method of guarding a governor is shown in Fig. 3, the guard being of perforated plate which is readily shaped and allows a view of the mechanism inside.

Placing a shield over the crosshead of engines is common practice and is advisable. In Fig. 3, at A, is shown a means of guarding the crossheads of a pump. The oiling platform is at B. These safety devices are all used by the United States Steel Corporation.

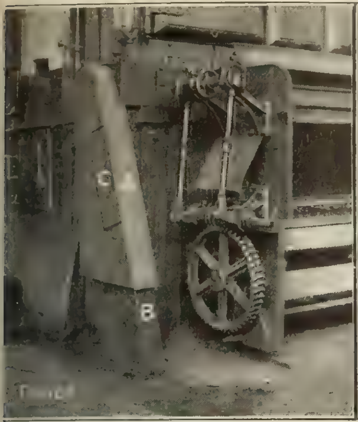

Fig. 4. Stoker-Chain and Sprocket Shield

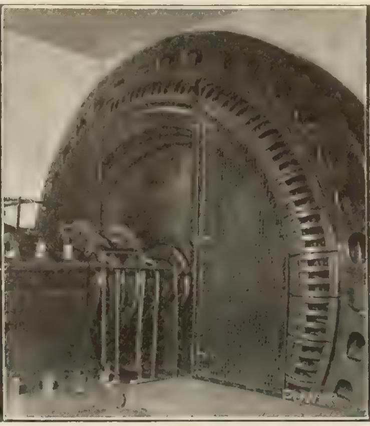

Fig. 5. Guards for Motor Rotor

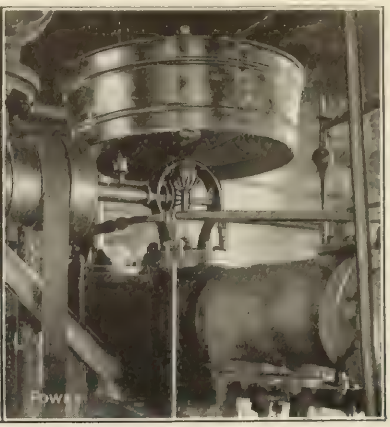

Fig. 6. Sheet-Iron Guard for Engine Governor

Chimney Capacity for Burning Waste Fuels

By David Moffat Myers

YNOPSIS—The amount of air or oxygen required for he combustion of waste fuel depends upon its chemical omposition, but the chimney capacity required depends n the character of the products of combustion. The reuired force of draft being known, the presence of moisure may add so much to the buoyancy of the escaping ases that the size of stack can, generally, be determined rom the usual chimney formulas for burning coal.

⁂

To burn anthracite coal, about 12 lb. of air is chemally required for each pound of combustible, assuming at the combustible matter is all carbon. Since, in tual boiler practice, 50 to 100 per cent. more air is dded to permit of more perfect mixing of the fuel gases ith the oxygen, the assumption of 12 lb. of air per ound of anthracite coal is close enough for all practical urposes.

Waste fuels of a woody or fibrous nature vary so great- from the composition of coal that the question of air pply requires special consideration. Spent hemlock tan ark is such a fuel and as it is quite extensively used for aking steam, consideration of the requirements for its ombustion may be of interest.

Dried samples of average tan bark yield the following nalysis within 1 per cent:

Carbon	0.52
Hydrogen	0.06
Oxygen	0.41
Ash	0.01
	1.00

The atomic weights of the elements concerned being H = 1, C = 12 and O = 16, assuming that the carbon burns to carbonic-acid gas, or CO_2, and the hydrogen to superheated steam or H_2O, the oxygen required is:

For the carbon

$$C + O_2 = CO_2, \text{ or } 12 + 32 = 44$$

i.e., the carbon requires $\frac{32}{12} = 2\frac{2}{3}$ times its weight of oxygen. As air by weight contains about 23 parts oxygen and 77 parts nitrogen, the air required will be $\frac{100}{23}$ times the oxygen required; for the carbon $\frac{100}{23} \times 2\frac{2}{3} = 11.6$ (say 12) times the weight of the carbon. So that to burn the carbon each pound of dry tan bark must be provided with about $12 \times 0.52 = 6.25$ lb. of air.

For the hydrogen

$$H_2 + O = H_2O \text{ or } 2 + 16 = 18$$

i.e., the hydrogen requires $\frac{16}{2} = 8$ times its own weight of oxygen, and the air required will be

$$8 \times \frac{100}{23} = 34.8$$

say, 35 times the weight of the hydrogen. Hence combustion of the hydrogen in a pound of dry tan bark requires about

$$35 \times 0.06 = 2.10 \textit{ lb. of air.}$$

It is to be seen, therefore, that the combustible ingredients require for combustion, per pound of dry fuel,

$$6.25 + 2.10 = 8.35 \textit{ lb. of air.}$$

But the fuel itself contains 0.41 lb. of oxygen, which is equivalent to as much oxygen as would be obtained from [illegible] × 0.11 = 1.78 lb. of air, so that the net chemical requirement of air will be

$$8.35 - 1.78 = 6.57\ lb.$$

of air per lb. of the dry fuel, or, only a little over half the air required per pound of anthracite coal.

But with tank bark each dry pound of the material as fired carries with it about 2 lb. of moisture, which being evaporated in the furnace, must be carried off by the chimney as superheated steam. This addition to the products of combustion occurs, however, after the draft has entered the furnace so that the presence of moisture while requiring no additional air supply requires additional chimney capacity for carrying off the steam thus generated and with induced draft, the duty of the fan would include handling the steam thus formed.

In designing a chimney for any fuel, attention should be directed first to the height required to obtain proper penetration of the fuel bed by the necessary air supply, as the rate of combustion is mainly controlled by the intensity of the draft, the latter being proportional to the square root of the height of the stack.

In the author's experience the best results in burning tan bark are obtained with a draft of 0.45 to 0.5 in. of water and the temperature of chimney gases is found to be sufficient to create this draft with a stack 150 ft. high. Having decided on a suitable height of chimney, the rate of combustion and the resistance of the fuel bed and draft passages, the diameter or cross-sectional area of the chimney may be found by applying Kent's chimney formula for burning coal, which is:

$$boiler\ horsepower\ of\ chimney = 3.33 \times E \sqrt{H}$$

in which

E = Effective area of stack in square feet;

H = Height of stack in feet.

This formula, which is founded on practice, is based on the consumption of 5 lb. of coal per hp. per hr. to allow for poor combustion, for a large excess of air supply and for forcing the boiler beyond its rated capacity. In using it the heat value of the fuel employed as compared with coal must be taken into account.

According to the analysis, burning 1 lb. of dry tan bark (3 lb. of wet tan bark) would yield 7950 B.t.u., whereas 1 lb. of dry coal gives about 14,000 B.t.u.* Therefore, to generate the same horsepower as 5 lb. of coal, there must be burned

$$\frac{5 \times 14{,}000}{7950} = 8.8\ lb.\ of\ dry\ tan\ bark$$

or 26.4 lb. of wet tank bark.

With fair combustion, 100 per cent. excess air may be considered as requisite for either tan bark or coal, and for 1 lb. of each fuel we have their respective air requirements and their consequent products of combustion measured by weight.

From the foregoing it is to be seen that the weight of the products of combustion of tan bark, i.e., of 1 lb. dry tan = 3 lb. wet, would be:

From dry tan burned. .	1 00 lb.
From moisture evaporated	2 00 lb.
From air chemically requir !	6 57 lb
From 100 per cent excess air	. 6 57 lb.
Total per dry lb. or per 3 lb. wet tan.	16.14 lb.

and the products of combustion for 26.4 lb. wet tan bark would be 142.03 lb.

The weights of the products of combustion of 1 lb. o coal would be:

From coal	1 lb
From air chemically required	12 lb
From 100 per cent excess air	12 lb
Total products of combustion for 1 lb. of coal	25 lb.

and the total products of combustion for 5 lb. of co would be 125 lb.

Owing to the liberal proportions of chimney derivabl from Kent's formula, the writer has known stacks fo burning coal to work satisfactorily at 50 and even 100 pe cent. over capacities as rated by that formula. In burning wet chips, tan bark and sawdust, the writer has als found that when the stack height is properly proportione for the fuel and for the local governing conditions, it size for a given horsepower capacity may be calculate directly by that formula. Although the total weight o the products of combustion of tan bark is greater than from the combustion of the equivalent coal, as has bee shown, the moisture alone causes the greater weight Moisture evaporated from the wet fuel makes a lighte column of hot gas in the chimney than would be made i dry coal were burned. Since the capacity of a chimne increases as its contained column of gases is lighter, compensating effect takes place when a wet fuel is burned

As the specific density of superheated steam is 0.62 as compared to 1 for air, if the chimney gases in the coal burning example be considered to have the same specifi volume as air, an idea can be obtained of the effect of th moisture evaporated from the tan bark both on the forc of draft and the capacity of the stack.

From the first table quoted the moisture or superheate steam constitutes $\frac{2.00}{16.14}$, or about 12.4 per cent. of th total weight of chimney gases. Hence, the weight ma be taken as

$$12.4 \times 0.622 = 7.7\ per\ cent.$$

for the contained superheated steam and

$$\frac{16.14 - 2}{16.14} = 87.6\ per\ cent.$$

for the remaining products.

The column of hot chimney gas from the tan bar therefore is about 5 per cent. lighter than that produce by the coal and, the temperatures being the same, the intensity of draft would be about 5 per cent. greater, bu the velocity of the gases and consequently the volume o gases discharged by the stack would be increased only t the extent of $\sqrt{\frac{100}{95}}$ or about 2½ per cent.

The foregoing leads us to the following conclusions:

1. Stack capacity for a waste fuel depends upon it chemical composition, and upon its degree of containe moisture.

2. The element of moisture in the fuel does not affec the capacity of a fan blower for undergrate draft; but i does affect the calculation of fan capacity for an induced-draft system.

3. Although a pound of the waste fuel may chemically require only one-half the air required by a pound o coal, the chimney gases resulting from its actual combustion may be greater in amount than those produced b burning an amount of coal having the heat equivalent.

4. In designing a chimney, careful distinction must

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*See author's paper "Tan Bark as a Boiler Fuel," Transactions of the American Society of Mechanical Engineers, Vol 31 (1909), page 685 be observed between required intensity of draft, which is proportional to the height of the chimney, and capacity or volume of draft, which is directly proportional to the effective area but increases only as the square root of the height; and that it is important first to determine the height of the stack in accordance with the nature of the fuel and the rate of its combustion. After this the diameter or cross-section may properly be calculated from the chimney formula with due consideration for the volume and weight of the gases.

5. A fuel of the composition of tan bark will require more or less chimney capacity than coal, depending upon its percentage of moisture content.

6. Moisture in chimney gases tends to decrease their density, but in some cases it may increase the capacity of the stack, and thereby compensate for its presence.

⁂

Bearing Metal Manufacturing and Use

By L. D. Allen[*]

SYNOPSIS—Cause and cost of friction Characteristics and classification of metals used for bearings. Requirements in the manufacture of bearing alloys.

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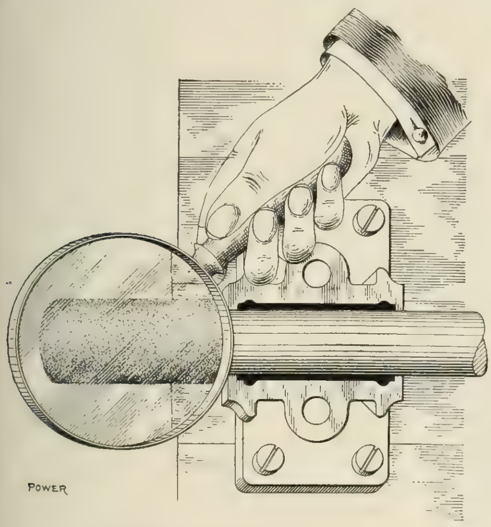
"It is not work that kills men, it is worry." It is not motion that destroys machinery, it is friction.



Magnified Section of Shaft

Friction, a destructive agent, constantly piling up waste and expense, is everywhere. And yet, of the many details connected with the operation and care of machinery, t is doubtful if any receive less attention than the reducion of friction. In many installations the shafting alone equires from 20 to 30 per cent. of the power developed y the engine and in some cases these figures are probbly greatly exceeded. Comparatively few realize the sigificance of these figures, which mean that of every ton f fuel consumed some 400 lb. or more are wasted in vercoming friction. Much of such waste can be greatly educed, but in the rush of getting out work such as preails in many mills and factories, few, if any, have the me and patience to go into details and correct bad conitions. The prevailing idea seems to be that greatest onomy will be effected by buying at a low price rather ian by securing efficiency and reduction in wear through ie use of suitable material and methods.

Power lost through friction is converted into heat which under normal conditions is radiated as fast as produced, the bearing surfaces remaining at or near the temperature of the surrounding air. If the heat is generated faster than it is dissipated, a hot or fused bearing will result. For this reason the antifrictional properties of a bearing metal are more desirable than tensile and compression strength. Many judge a metal by its compression strength and its tin content, whereas, under high speed, metals high in tin are usually the first to heat and fuse. It makes no difference how much tin a metal contains, how hard it is or how great its compression strength, if it heats it will soon fuse and run out of the bearing and under such conditions it is no better than so much lead.

Cause and Cost of Friction

Resistance to motion, friction, is great or small according to the roughness or unevenness of the surfaces in moving contact. In reality there are no absolutely smooth metal surfaces. A surface may seem smooth to the touch, but by means of a powerful lens, minute projections, roughness and unevenness may be seen, as illustrated herewith, which create the resistance. By proper lubrication a film of lubricant is established and maintained between the rubbing surfaces which tends to prevent the irregularities from meshing. The conditions for this film are favorable only to such extent as the bearing and shaft are smooth.

To a greater extent than most people realize the "cost of the babbitt or the lubricant is the cost of the friction accompanying the same."

A concern may spend several dollars less per hundred pounds for a babbitt that will show apparently satisfactory wear, but the question is how much money does this concern spend on other things as a result of the friction developed from the use of this particular babbitt. It may not even heat in a slow-running bearing, but if it is low in antifrictional qualities it communicates to the other parts of the machinery a certain amount of pull and drag and this percentage, even though small in any one bearing, develops to considerable proportions in the aggregate friction of all the bearings throughout a plant.

Babbitt Requirements

The requirements of a babbitt are: First, that it be composed of metals least susceptible to frictional contact; second, that it possess the sustaining properties necessary to carry the load imposed; third, that the ingredients be so treated, reduced and combined as to produce an even, smooth, unctuous surface, which will minimize interlocking, abrasion and friction in its various forms.

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[*] Antifriction specialist, Chicago, Ill.

The metals used in the manufacture of the various babbitts, type metals, solders, etc., are two or more of the following: Tin, lead, copper, antimony and bismuth. Some idea of the bearing value of these different metals may be derived from the properties of each as enumerated herewith.

PROPERTIES OF TIN

Tin is a white metal with a yellowish tinge. It toughens the alloy, lowers the melting point and assists in producing a strong, homogeneous mixture. It is a "dry" metal, that is, somewhat lacking in antifrictional properties. Under heavy friction it heats quickly and fuses. Over direct heat it melts at about 450 deg. F.; its specific gravity is 7.35. The grade generally used in the manufacture of babbitt metals is known as Straits tin. There are now in this country a number of detinning concerns which are producing a nearly pure tin by either a chemical or sweating process from old scrap, tin cans, etc. This is now being used extensively in the manufacture of babbitts and cheap solders, as it can be bought at about a cent per pound under the market price.

LEAD

Lead is another ore product and imparts softness, lowers the melting point and reduces the tendency to heat. It reduces friction more than any other metal, resembling graphite in this respect. It melts over direct heat at about 620 deg. F., and its specific gravity is 11.38. In many sections considerable antimony ore is found combined with the lead ore, so that in the process of refining the lead a slag or byproduct results, which is known as antimonial lead. This is put through a further refining process, which does not separate the lead from the antimony, but removes considerable of the impurities such as iron, arsenic, etc. The resultant product usually contains anywhere from 12 to 22 per cent. antimony, the rest being lead and some impurities. This antimonial lead is used in making cheap babbitts, type metals, casting metals, etc., for competition where a low price is necessary.

COPPER

Copper hardens and toughens the alloy and raises the melting point. It slightly increases friction. It melts at a temperature of 1943 deg. F., and its specific gravity is 8.85. Copper is the basis metal in bronze, brasses, etc. Very little of it is used in babbitt metal, from 0.25 to 0.5 per cent. in a lead-based babbitt, although there are some mixtures that contain as much as 10 per cent. copper, the hard babbitt, for instance, known as "Hard Genuine," containing 80 lb. of tin, 10 lb. of antimony and 10 lb. of copper. Copper and lead are not particularly fond of each other. The writer does not care for copper in a lead-based babbitt; it hardens the babbitt somewhat, but it reduces the antifrictional value.

ANTIMONY

Antimony is an imported ore product. It is a hard, brittle, bluish-white metal of crystalline structure. It hardens an alloy and raises the melting point. It is a great reducer of heat and it also reduces friction. It melts over direct heat at about 1169 deg. F., and its specific gravity is 6.76. The crystalline grain or fracture in a babbitt is due to its antimony content. Some very carefully and scientifically conducted tests indicate that the best babbitts should not contain over 13 per cent. antimony, as the evenness of the alloy and its wearing qualities are greatest at that point.

BISMUTH

Bismuth reduces friction and prevents shrinkage. It lowers the melting point and expands on cooling. It melts at a temperature of about 507 deg. F., and its specific gravity is 9.82. As bismuth usually costs more than $2 per pound, it is not at all popular with the babbitt manufacturer.

ALUMINUM

Aluminum is rarely used in a babbitt. It imparts some toughness by closing the grain and acts as a flux. It slightly increases the friction which offsets its toughening properties and makes it of no practical value in a babbitt.

Certain combinations of tin, copper and antimony shrink on cooling. Tin and lead alone shrink slightly and antimony remains about constant. Any two metals mixed together in the form of an alloy produce a metal which melts at a lower temperature than the original metal having the higher melting point and in some cases, lower than the metal with the lower melting point.

CLASSIFICATION OF BEARING METALS

Bearing metals or linings may be classified under two heads, babbitt metals, which are largely tin, lead, antimony and sometimes copper compositions, and brasses and bronzes, which are tin, copper and zinc compositions, sometimes containing certain percentages of lead.

Babbitts range in composition from a cheap metal containing 90 lb. lead and 10 lb. antimony, to mixtures containing about 88 lb. tin, 4 lb. copper and 8 lb. antimony.

Babbitt metals are divided into three classes, the lead-based antifriction metals, which are metals in which the lead content is the heaviest, the smaller percentages being tin and antimony; the semi-tin-based metals in which the tin and lead contents are about equal, leaving room for from 10 to 20 per cent. antimony, and the tin-based metals, which range from 75 lb. up to 90 lb. of tin in each 100 lb.

I have knowledge of over 200 different babbitt mixtures that are in actual use, whereas only about seven or eight are really necessary. Babbitt metals should be made according to certain exact percentages, or so constructed as to be evenly balanced, so as to produce perfectly homogeneous mixtures or alloys, in order that a combination may possess its maximum strength and hardness.

BEARING-METAL MANUFACTURERS

There are four kinds of bearing- and type-metal manufacturers.

The first is the smelterer who buys and refines drosses, scrap metals, etc., and converts the resultant product into different grade of babbitt metals, type metals, solders, etc. He sells to a large trade, which is influenced or attracted by a low price; its requirements are large in the matter of quantity, but not exacting in the matter of quality.

The second, is the man who installs a kettle, buys tin, lead and antimony and mixes them in certain proportions according to some one or set of published formulas. Not only are these published or analytical formulas, as a rule, incorrect, but they have very little to do with the details of producing the right kind of finished product. The amount of business he does is in proportion to his luck and hustle.

The third is a combination of the two foregoing classes.

The fourth is the experienced alloyist who has studied the properties of all the different metals, so that he knows which will combine best and how best to combine them—the best temperatures and fluxes to employ, etc. He has also, to combine with the foregoing data, a practical knowledge of the uses to which the metals are put. This type of man gets the discriminating, careful trade, which makes a thorough study and test of its needs and demands results accordingly, or which, in buying, places quality first.

Manufacturing Requirements

Many years of practical experience with the formulas and manufacturing methods employed by different babbitt manufacturers both in the United States and abroad, coupled with deductions from results shown by expert analytical and mechanical tests and under actual working conditions in nearly all kinds of machinery, indicate conclusively the following facts:

The best amalgams are produced by the alloying method. This requires the use of several furnaces, pure materials, and consists in making up, at suitable temperatures, certain primary combinations of affinity metals; then taking such quantity of each combination as is necessary to produce the required grade and alloying the same under suitable temperature into the finished product. Metals may be well mixed but the quality and permanency of the mixture are determined by just such solubility laws as control ordinary solutions. Certain perfect amalgams at high temperature become partly separated amalgams at low temperature; others there are that remain perfect amalgams at any temperature.

In the use of the lead-antimony and the lead-antimony-tin mixtures a complete reduction of the crystal formation is important to insure smooth mirror-like nonabrasive bearing surfaces. All the ingredients must be evenly balanced and distributed throughout the alloy. It is for this reason that a lengthy annealing period is desirable because it has been found to have a greater effect on the mechanical properties of a metal than the temperature factor.

The tin, copper, zinc, aluminum, nickel, etc., amalgams are the most difficult to produce. They require skill and care in the introduction of deoxidizing agents, such as magnesium, phosphorus, silicon, etc.

Virgin vs. Old Metal

Very often large babbitt users who have their own formulas specify that "virgin" metal be used. Metallurgists claim that it is not a question of whether virgin metal or old metal be used so long as the metal is "pure," free from dissolved or mechanically entangled oxides. It is the oxides and impurities that impair repeatedly overheated or remelted metals. Some good authorities claim that the dross of tin, lead and antimony products (when free from iron, aluminum, zinc and arsenic) and smelted in an adequate reducing furnace at above 2500 deg. F., will, with the proper additions made to the resultant metal, produce amalgams that are superior to the same amalgams made from all virgin metals because the amalgams will be better alloyed than when virgin metal is used. My experience, however, leads me to doubt this and to believe that chemically pure, perfectly balanced amalgams made of virgin metal produce the surest and strongest babbitt metals made and that they possess higher antifrictional properties.

Chemical Analysis Alone No Guide

A babbitt should not be selected on analysis, as there is much that enters into the making of the metal and that has to do with its physical properties that evades the chemists. Nor should one babbitt be selected for all bearing requirements. Metals heavy in lead are best antifrictionally when properly alloyed, but metals heavy in tin and copper are also desirable where toughness combined with hardness is required to meet unusually severe or irregular bearing conditions.

Considering the price of lead and antimony, there is no legitimate reason for paying 18c. to 25c. per pound for bluish-looking or leady-looking metal, the tin content of which is usually not over 15 per cent. and often below 10 per cent. On the other hand, considering the high price of tin, no one should expect to pay much, if any, below the market price of tin for the whitish-looking or tin-based metals, or a medium figure for the semi-tin-based metals which are also white in appearance.

Babbitt troubles are often due to a good many things other than the babbitt itself. Some of these things are a selection of the wrong grade of metal; the wrong application of the metal; irregular bearing conditions; bad lubrication; neglect, etc.

The safest course for the purchaser who wishes to secure the best bearing values is to place his babbitt orders with such manufacturers only as are thoroughly experienced in bearing requirements, who know just what metals or combinations of metals possess the best endurance and antifrictional properties, who are also thoroughly skilled in alloying and combining metals, and, as well, honest and conscientious in their trade relations.

Prices and analyses are usually dangerous factors to rely upon in the selection of a babbitt. The size of the bearing, the thickness of the lining and the speed and load conditions should influence the choice. A properly made, hardened and strengthened lead-based babbitt will, ofttimes, due to its naturally better antifrictional properties, give better service than an expensive tin-based metal.

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San Diego Exposition—The many exhibitors and concessionaries at the San Diego Exposition have been notified that all buildings for exhibits or concessions must be ready for installation by July 1, 1914. Four of the big exhibitors are working on the grounds, and some of the concessions have been begun. Another month will see the completion of the great reinforced viaduct over Cabrillo cañon, at the west entrance to the exposition, permitting the hauling of material for the remainder of the construction work over a much shorter and easier route, and giving easy access to visitors to the grounds. The exposition work is now nine weeks ahead of schedule and the plantations and ground work are 85 per cent. complete. Commissioners are now scattered over the United States, Europe and Central and South America, securing industrial and commercial exhibits, exhibits of the arts and crafts, archaeological and ethnological specimens, manufactures and horticultural and agricultural exhibits that will fill the exhibit buildings. Many spectacular features are being secured.

Feeding Refrigerating Coils*

SYNOPSIS—Various methods employed in the direct-expansion and flooded systems, and something on the merits of the apparatus used.

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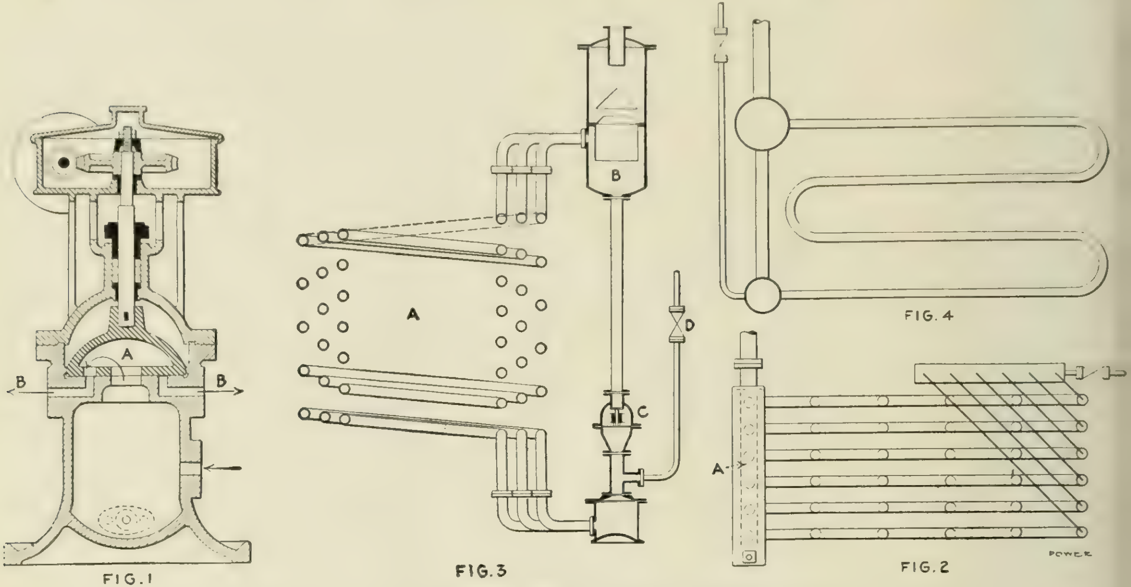
Feed systems for the refrigerator or expansion coil may be divided into three groups: The forced-feed or direct-expansion systems, the gravity-feed or flooded systems and systems which are a combination of the two. In any of these systems the refrigerant is admitted to the refrigerator coil by means of a regulating valve or cock. This valve is likely to clog up with dirt from the system, and it is practically impossible to so adjust a number of expansion valves feeding from a main liquid-supply pipe as to obtain an equal supply of refrigerant to each refrigerator coil connected to it.



Details of Apparatus and Systems for Feeding Refrigerating Coils

In Europe there is an appliance which overcomes most of the objections of the regulating cock or valve, in an apparatus which distributes the refrigerant to a number of coils of equal length by means of a revolving disk, which rotates over as many holes as there are coils. The disk has one hole which allows the refrigerant to enter each coil once during one revolution. Fig. 1 shows a section of this apparatus, in which *A* is the disk showing the inlet hole or opening over one of the distributing openings *B* in the body. These holes are arranged in a circle of the same radius as the inlet hole from the center of rotation. It is claimed that this apparatus makes a system 20 per cent. more efficient than when equipped with ordinary expansion valves. Doctor Linde, the inventor, is also the originator of a single rotating cock which works on the same principle.

In practice, refrigerator coils are fed in some cases from the top, and in other cases from the bottom. The top-expansion system has not been found more efficient than the bottom expansion system, and in operation there is a chance of carrying liquid over to the compressor. The first named has been employed mainly in connection with horizontal compressors where wet gas has been preferred for operation, also where the forecooling tank coil of an ice-freezing system is so arranged that the return gas of the ice tank may pass through on its way to the compressor. The bottom-expansion system has been used by some builders of vertical compressors and in cases where dry gas is essential to the successful operation of the compressor. In this connection may be mentioned a system which will be called a horizontal-feed system. Its arrangement is shown in Fig. 2. It is fed by only one regulating valve. This system is used in a can-ice tank, and there is another similar arrangement for the same purpose, but in this case each horizontal coil has its own regulating valve.

The deficiencies of the force-feed system, relative to proper feeding of a number of coils with one regulating apparatus or a number of coils with a regulating valve for each coil, are overcome by the gravity-feed or flooded systems, and besides, a greater part of the cooling surface is made efficient because the pipe is not needed as liberating surface. The invention of the first of these systems in this country dates back to the late eighties. Unfortunately, the inventor, H. J. Krebs, was not encouraged with the results obtained during the first tests as to the merits of the new system, and consequently further tests were abandoned, and the system was forgotten for years. Judging from the patent papers, it was well designed and would perform its duty today, but without the float-operated regulating valve for ammonia. For sulphuric-acid gas systems this float arrangement would probably have worked much better, as a larger quantity of refrigerant is required for the same number of heat units. This would not necessitate such a closely set opening, and again the difference in pressure between the incoming liquid and the refrigerator coil is about one-third that in an ammonia system. Apparently the float arrangement was replaced by an ordinary feed valve, and in this shape the system was manufactured, at least during the last few years of the life of the patent.

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*Abstract of paper read by S. H. Baars before the American Society of Refrigerating Engineers.

Two other gravity-feed systems are in use today which have the same advantages as regards the facility of feeding a number of refrigerator coils at the same time. One system patented by the late H. Rassbach has, as a special feature, the precooling of the refrigerant for the purpose of preventing excessive spraying of the entering mixture of liquid and vapor, the vapor being created by the sensible heat of the refrigerant.

The third system admits the refrigerant directly into the refrigerator coil and forces the vapor, liberated by the sensible heat of the liquid, to pass through the entire coil. The unevaporated liquid is allowed to return through a check valve. To make this third system equally as efficient, the circulation, and therefore the heat transfer, must be more rapid so as to take care of the losses due to the larger volume of vapor in the coil and a higher evaporating temperature.

Gravity-feed systems were also patented in Europe. The one patented by Schmitz in 1903 seems to be analogous to and of an earlier date than the third system mentioned. In Fig. 3, *A* represents the refrigerating coil, *B* the accumulator or separator, *C* the check valve and *D* the feed valve.

Professor Pictet also used in his binary system of refrigeration an arrangement which might be classed as a gravity-feed or flooded system; including the headers, it is identical with the aforementioned system. The suction and liquid headers were connected by a large vertical tube or so called accumulator, into which the liquid was fed. The system also met with a fate similar to the one designed by Krebs. The trouble was faulty construction of the coil so that it did not provide for a continuous upward movement of the refrigerant, causing the coil to become gas-bound and to offer too much resistance for the small liquid head.

Besides these two foreign systems, there are several operating more or less on the flooded principle. One of them is shown in Fig. 4. Here are two wide headers; the liquid enters the lower header and the vapor generated by the sensible heat of the liquid escapes through a large connection directly into the suction header. Otherwise the operation is the same as in the other gravity-feed systems.

Besides the force-feed and gravity-feed systems there are several combinations of the two, such as shell-type brine coolers, which can easily be operated flooded because they have a large liberating surface. A separator in the suction line, with a liquid-return connection added, will certainly insure as good a heat transfer as any gravity-feed system.

To improve the direct-expansion systems a separator has been installed in the main suction line leading to the compressor, but at such a height that the separated liquid can flow by gravity to a coil of sufficient surface to take care of its evaporation. The return of this coil goes back to the separator. The separator and the coil are on the true gravity-feed principle, with the exception that the refrigerant does not come direct from the liquid line, but from overfeed direct-expansion coils, the capacity of which had to be increased for some reason without increasing their surface.

An apparatus for the same purpose, but so arranged that the refrigerant is returned to the same refrigerator coil, has been in use in Europe since 1896. A diagram of the arrangement is given in Fig. 5. It has proved to be even more effective than the flooded system patented by Schmitz. In the drawing, *A* is the regulating valve, *B* the refrigerator coil, *C* the separator, *D* the pump which returns the unevaporated liquid to the refrigerator coil, and *E* is the suction line to the compressor.

As a development of the above, an apparatus has been designed which does all this automatically and also does away with the pump. In Fig. 6, illustrating this apparatus, *A* represents the suction from the refrigerator, *B* the separator, *C* the suction to the compressor, *D* the connection for unevaporated liquid to the regulating apparatus and *E* the equalizing line necessary to allow the returned refrigerant to enter the regulating apparatus. In this apparatus there is a rotating feed cylinder *F* which has three chambers, each with one hole in the top and the bottom; the sections *ab* and *ef* show the holes in the top and the bottom plates between which the cylinder rotates; section *ef* shows connection *G* from the liquid supply valve and *H* to the refrigerator.

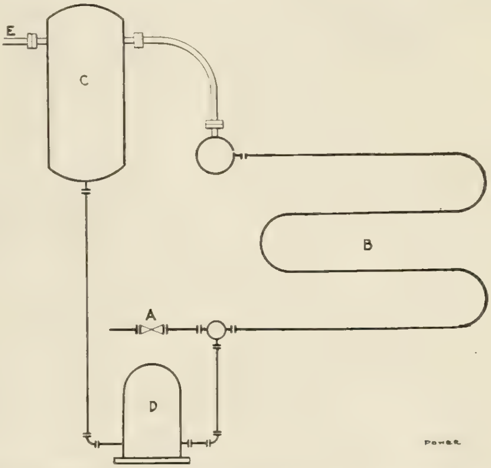

Fig. 5. A System with a Separator for the Liquid Refrigerant

The feed cylinder is operated by a gear, and to get an idea of the working of the automatic regulating apparatus, the different phases of operation may be studied for one chamber during one revolution. Starting with the chamber in the position at the left side of the elevation, as in Fig. 6, it will be observed that the unevaporated liquid can enter the chamber and fill it with as much liquid as there is present in the separator *B*, which is equalized with the chamber *F* through the equalizing pipe *E*. Assuming that the cylinder rotates in the direction of the arrow, the next opening to be passed is that which registers with the opening from the condenser, and here the high-pressure liquid fills out whatever space there is left by the liquid returned from the system. Through communication with this opening, the refrigerant in the chamber is brought into connection with the condenser outlet and given the necessary pressure required to make it flow into the chamber below, which it does in passing the third opening, where it registers during the next one-third revolution. Connected to the lower chamber is the liquid supply pipe of the refrigerator coil into which the refrigerant passes to perform its refrigerating duty and in which it is partly evaporated. After leaving the refrigerator coil it again passes to the separator *B* where the gas passes to the compressor, and the unevaporated liquid again passes out through *D*, beginning another cycle of operation. The cycle is repeated with sufficient rapidity to properly feed the respective refrigerator coil. The simplicity of the regulation is due to the fact that if so much liquid is returned from the refrigerator coil as to completely fill the chamber of the feed cylinder, then there will be no refrigerant added while the chamber is in communication with the opening to the high-pressure liquid inlet, but the pressure required to make it flow into the lower chamber is transmitted to it just the same through the condenser connection.

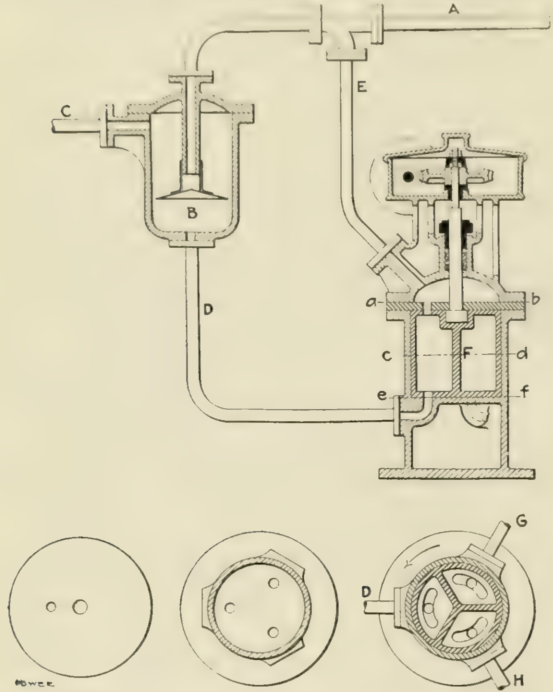

Fig. 6. Automatic System Requiring No Pump

From the foregoing it can be seen that the designer's aim would seem to be to install a feed system which will have the cooling surfaces covered with the liquid refrigerant. There is another question to take into consideration, however, and that is the shape of the evaporating surface. As pipes are the most convenient surface the proposition reduces itself to the selection of the proper diameter of pipe to use, and here is the question: What pipe will give the largest surface for the least amount of liquid refrigerant, if the refrigerant is an expensive one?

In the accompanying table, line 1 gives the internal surface, in square feet, of pipes of various sizes containing one cubic foot; line 2 gives the cross-sectional area of the pipes in square feet, and line 3 the number of lineal feet of the various sizes for the number of square feet of internal surface given in line 1. It can be seen that the smaller the pipe, the smaller is the opening through which the refrigerant, evaporated by a given surface, can escape. This point is important as the pipe size has a great deal to do with the pressure required to circulate a liquid or vapor through a coil.

INTERNAL SURFACE AND AREA OF PIPES

Full Card Weight Pipe

Nominal Diameter, In

	½	¾	1	1¼	1½	2	2½
1	77.3	58.5	45.9	34.8	29.85	23.2	19.6
2	0.0021	0.0037	0.0060	0.0104	0.0141	0.0233	0.0332
3	473.8	270.0	167.2	96.26	70.73	42.91	30.34
				Extra-Heavy Pipe			
1	88.5	66.3	50.5	37.75	32.1	24.85	20.75
2	0.0016	0.00295	0.0049	0.0088	0.0122	0.0204	0.0292
3	623.0	338.6	202.8	113.3	82.1	49.05	34.2

With the aid of the table it is possible to select the right pipe size for the refrigerator coil if the heat transfer is taken into consideration. For instance, one would probably select a ½-in. pipe for air cooling in which the coils are very short and large in number, and a 2-in. pipe for a coil in a long ice tank. After considering all this, the cost of the refrigerant may be balanced with that of the pipe coil and a final selection made.

From what has been published about the gravity or flooded system, one would infer that there are no further data required for their proper design, but as yet there is no information available which explains the relation between the height of the liquid level above the refrigerating coil and the velocity of the refrigerant in the refrigerator coil. There are so many varied conditions, due to length of coils, diameters of pipe and heat transfers under different conditions, that quite a field is open here for a careful study and for elaborate tests to improve this part of the feed system.

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Measuring Air Velocities

Although the anemometer is not generally considered an accurate instrument, it is convenient to use and if carefully handled will at least give approximate results. A committee (C. A. Haslett, chairman) of the American Society of Heating and Ventilating Engineers recommends the following as a guide in using the instrument for measuring velocities at air-supply openings:

The opening should be divided into equal rectangular areas; no side of which shall be over 10 in. long, excepting where this would require more than 12 readings, in which case the opening shall be divided into 12 equal areas.

Readings are to be taken in each case at the center of each area.

Readings are to be of one-half minute duration, the anemometer being held against the register face or in the plane of the opening.

Where a diffuser is used, the total area is to be computed on the basis of the periphery of the diffuser.

The average of the readings is to be considered as the average velocity at the opening. Where negative velocities are found they are to be deducted in arriving at the average velocity.

In computing volumes, the net area of the opening is to be taken, the volume to be considered as the product of the average velocity and the net area of the opening.

If the anemometer is held 2 in. from the register face, no deduction shall be made for the area occupied by the register mesh.

Editorials

Safe Boiler Support

The importance of safe boiler support is not generally recognized, and the boiler laws that have been enacted in the various states and municipalities, do not seem to have taken into account its influence as affecting the safe operation of boilers. Anyone familiar with boiler explosions will be sure to feel that if a boiler should fall down while under steam, an explosion would be almost certain to follow; yet it is rare to hear this cause advanced as the explanation of boiler explosions where other causes are not in evidence. It seems more than probable that a good number of mysterious boiler explosions, occurring with sound boilers and where there has been conclusive evidence that no overpressure existed, may have been due to the falling down of the boilers or their changing position to such an extent as to result in the breaking of the pipe connections, thus producing the explosion of the boiler.

Investigation into the conditions surrounding the explosion of two sound boilers recently, seemed to indicate that the falling down of one of the boilers was the only reasonable explanation for the accident. These two boilers exploded simultaneously, the explosion of one having undoubtedly been the cause of the explosion of its mate. The tears through the shells of both boilers were similar, occurring through the top manhole reinforcement, which was of the outside pattern, and weak. The girth rivets at each end of the course that contains the manhole opening were sheared. All parts of the shell that were fractured were without evidences of defects, the tears being through the solid plate. Calculation showed that the structure should have stood about five times the load due to the steam pressure that was on the boilers at the time of the accident, and that there was not an excess pressure at this time was clearly indicated by the condition of the pop safety valves that were attached to the boilers. One boiler showed distinct marks on the manhole course of having been dented by a blow delivered to it by the manhole frame of the adjoining boiler when it exploded. From the nature of the breaks on these boilers, it is probable that the main steam connection on one boiler was broken by the falling down or settling of the boiler. The sudden opening and the resulting outrush of steam, caused a wave action of the water in the boiler, which resulted in its rupture girthwise and the manhole course lengthwise through the manhole reinforcement. This explosion probably would have been prevented if the boilers had been properly hung instead of depending on the settings for support.

The Massachusetts and Ohio rules prescribe that boilers above 78 in. diameter be hung, and that the support be independent of the setting walls. This provision was evidently made for fear that such large boilers could not be safely supported on the setting walls, which is doubtless correct. It would also seem to be a reasonable precaution to have all sizes of horizontal tubular boilers hung. The smaller size boilers are usually installed in the smaller plants where the condition of the settings is not as apt to be so closely watched as in the larger plants and small boilers for this reason are probably more likely to be exposed to the danger of explosion from improper support than larger boilers.

The American Boiler Manufacturers' Association, at its twenty-fifth convention, proposed that the Massachusetts Rules be modified in regard to the requirements for hanging boilers and that the boiler manufacturers be allowed to follow the present practice, which had been proved safe. Such a move would seem to be a step backward, and if any change is made it should be to require that the smaller sizes of boilers also be hung. It requires more than the mere statement of the boiler manufacturers to show that lug-supported boilers are safe, for there have been many instances to show that this means of support has often been the initial cause of boiler explosions.

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Chimneys for Oil Fuel

Oil fuels have many advantages over coal, particularly for steamships and locomotives. For power-house work, they also promise decided benefits, many of which have been realized already and others will be when more is known of the art of burning oil.

The art of burning oil is comparatively new and calls for quite different conditions and design of plant than for coal burning. The important and governing condition in the economic use of oil fuels is the regulation of the air supply for combustion and the importance of this cannot be too strongly emphasized. Tests of many existing oil-burning steam power plants bring out two interesting facts; that the height of chimney necessary for adequate supply of air for combustion is much less than usually supposed or as usually installed; and, that the height required for plants subjected to frequent and severe overloads is considerably greater than has been ordinarily provided.

The high chimney, though supplying air in excess of that required for load or underload conditions, permits heavy overload and hence is particularly adaptable to city use where other conditions as well make the high chimney imperative. The greatly varying power requirements of city buildings due to lighting, elevator, ventilating, heating service, etc., can thus be taken care of by the tall chimney—the only type of chimney that can be installed. Even under such severe conditions, however, the chimney draft has been found to be excessive in many installations and more economical results obtained when the stack diameter has been somewhat reduced or the equivalent result obtained by constricting the cross-section by installing a damper. Securing the effect of reducing the chimney diameter in such cases simply reduces the air supply for combustion, again indicating that past practice has erred toward too great an air supply and that no rules for proportioning chimneys for satisfactory capacity when burning oil have yet been derived.

Economy, Real and Fancied

In the pursuit of the will-o'-the-wisp of economy in steam power plants, many fall into the bog of devotion to the one idea of low steam consumption. Let the designers of prime movers strive for that characteristic in each of the several types they produce, but the engineer to whom is entrusted the selection of the power-generating equipment for any given conditions has many other considerations to weigh against this one. Interest on the investment, depreciation and all of the multitude of costs that come under the head of maintenance, including labor, all too often are lost sight of in the effort for the greatest fuel economy. Locations there are where the high cost of coal justifies a heavy outlay for the most refined equipment, regardless of its expense and the space occupied and, then again, there are the places where the value of the land, with taxes and insurance, demand a compact installation. Much more common, however, are the situations where neither the fuel expense nor the property value are the main considerations.

It becomes ridiculous, as in the two illustrations mentioned in Mr. Longwell's paper on page 317, to seek to improve steam economy when the fuel costs nothing and there is use for low-pressure steam in excess of the amount available from the exhaust of prime movers. Evident as may seem the folly of substituting more efficient engines in such instances the fact remains that it took argument to dissuade those contemplating the changes from making them. Generally it is far less easy to distinguish between real and fancied economy and it is for that reason that the plea for a more rational study of each individual problem needs repeated vociferation.

It is a rare delight to us to be able to reprint such a paper as the one referred to, for the benefit of our readers and we cannot too strongly urge a careful reading of it. While the particular problem it discusses may concern a relatively small number and it would not be safe to take the conclusions it arrives at as applicable to many, if any, other fields or industries, for "circumstances alter cases," still, the method of analysis is so thorough and the treatment throughout so abounding in common sense, that it cannot help but be of value in a suggestive way to any who may now, or later, face the perplexing question of deciding what they should substitute for, or add to, their present installations. The important lesson to be gleaned from it is that it is dollars, and not pounds of coal, or pounds of steam, that is the true measure of economy and that this measure has not been properly applied until the problem has been examined from every angle and every contributing influence has been given due consideration..

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Engine Inspection

A number of states and municipalities have laws which require that boilers be inspected by duly certified inspectors and certificates issued to permit their operation for a definite period of time. It would seem just as logical to require that engines also be regularly inspected to see that their operation is such as to comply with the usual and necessary precautions for safety. Why is it not just as necessary to protect life and limb from the results of flywheel explosions as from boiler explosions? The experience of insurance companies covering losses from these two kinds of hazard, show that a serious accident is more apt to be caused by the explosion of a flywheel than that of a boiler. A moderate size engine with a large flywheel can store about the same amount of energy and is as capable of damage to life, limb and property as a small boiler. It is true that the path of probable damage in case of the flywheel explosion lies within more or less well defined limits, but the destruction within these limits is usually complete.

While it is a fact that where boiler laws are in force engineers' license laws are also effective, from the kind of examination questions usually asked the applicant for a license, it would seem that the intent of the examiner was to ascertain if the applicant could operate a plant economically rather than safely. Reasonable state or municipal requirements, regarding the application of safety appliances to prevent the racing of an engine, together with competent inspections, rules to govern the location of engines in the case of new installations, so that places likely to be occupied by a number of employees or the public would not be specially hazardous in event of the flywheel exploding, should be welcomed by all truly interested in "safety first."

⁂

Examination Questions

Anxious inquiries have come to us from places where engineers' license laws are about to go into effect, as to questions likely to be asked in the examinations. We cannot, of course, forecast the line of questions, which an examiner may see fit to propound, nor would the delivery of ready-made answers be to the best interest of all concerned. The questions are, or should be, framed for the purpose of determining whether the applicant is a *safe* man for the place or not.

The examiner should not concern himself whether the applicant has a vast fund of engineering information ready for immediate delivery or can capture all the elusive British thermal units and induce them to work overtime or not, that is the employers' side of the question. "Public safety" is the objective. Therefore, any engineer who knows that he can operate with safety a plant of the class for which he is seeking a license need have no apprehension in regard to the examination. The factors of safety to be demonstrated are good judgment and attentiveness. The first is based on training and knowledge of the principles involved and must be demonstrated to the examiner. The other is usually vouched for by two reputable citizens.

It is the privilege of the examiner to test, in any way he may think best, the mental alertness of the applicant, and he is sometimes justified in resorting to "catch questions" (like applying tension to a spring to observe the "come back"), but their use and weight should be limited. Best results are obtained by straight-forward, pertinent questions, answered as concisely as possible, without an effort to appear overwise, or to evade.

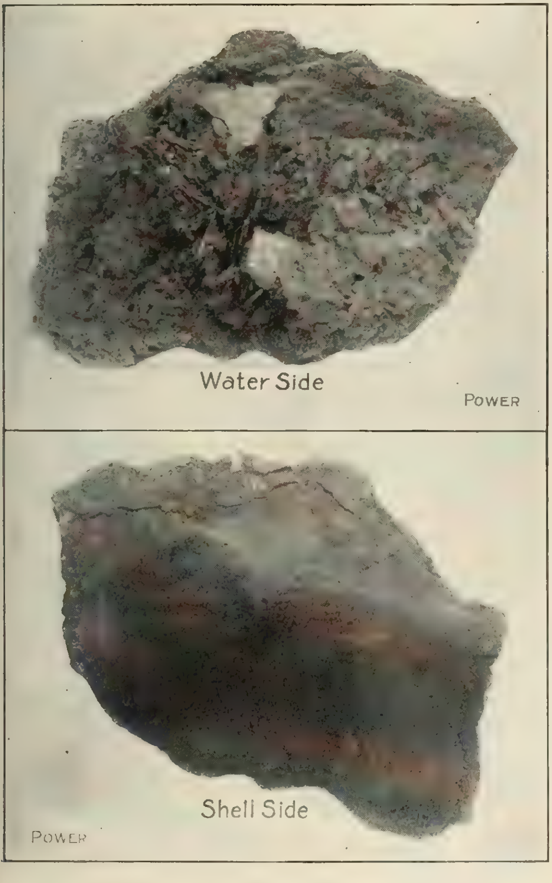
⁂

Those who have long advocated high boiler settings will be glad to know that the practice has received substantial approval by the designers of the new 201st St. station of the United Electric Light and Power Company, New York City. The tubes are ten feet above the stokers at the rear of the furnace.

Correspondence

Scale Removed by Graphite

The photographs show the front and back views of a piece of scale taken from the bottom front end of a 30-ft. x 8-ft. Lancashire boiler on which we have been using graphite for about three months. This boiler is one of a battery of three, fed from a dirty river, the water from which leaves moderately hard scale which formerly had to be chipped off, but since using graphite the boilers are as clean as it is practicable to get boilers. What little scale remains may be easily brushed or scraped off; it is not necessary to use a scaling hammer. On examining the front view it will be seen how effectively the scale has been driven off the shell plate and flues and collected in layers on the bottom of the boilers. The step caused by the butt strap, and several indentations in the plate caused by the unskilled use of a chipping hammer were visible on the back of the scale.



Scale Removed by Graphite

E. Russell.

London, England.

A Solicitor's Experience

In the editorial of Jan. 20, entitled "What Engineers Want to Know," six reasons are given why contracts are made by large users of current with public-service corporations. A very frequent reason for the existing condition of affairs was omitted, however; this is the influential stockholder owning stock in both the selling and the purchasing company.

The writer had an experience in Worcester, Mass. some years ago, when soliciting the contract for heating and power equipment from the owner of a large department store. After figures were submitted, showing the financial advantage of installing a private power plant, which are readily acknowledged, the owner remarked:

"You may not know, but my father is a large stockholder in the local electric light company here, and we would not think of setting a bad example for our fellow citizens by installing our own plant.

"Even if it costs the store more, we think our interests lie in doing all we can to increase the business and prestige of the lighting company, thereby conserving our stock interest in that company as we personally will get it back in dividends."

If you seek deep enough, you will generally find some such condition behind "inexplicable" contracts.

Ira N. Evans.

New York City.

Inertia in the Boiler Room

Inertia is that property which tends to continue a body in a state of rest or motion until acted on by a force. Few realize the importance of this law of mechanics. If we wish to tighten a hammer on its handle, we hold the handle in one hand and strike the opposite end from the hammer with another hammer and the handle is driven into the eye. This is owing to the inertia or resistance of the hammer to sudden motion as compared to the inertia of the lighter handle. Everyone knows how much more effective a jar is than a steady pull on the wrench handle in removing an obstinate nut, all of which is due to inertia. Many more illustrations could be cited, but one more will be sufficient.

A boiler inspector in a Pennsylvania coal-mining district was relating the ingenuity of the average imported citizen in overcoming common troubles in boiler operation; he had discovered them using an original method for properly seating lead gaskets on manhole openings of boilers. Those gaskets when new were found frequently to be poorly fitted and to leak.

With such troubles the need for removing the gasket was avoided by setting up tight on the bolts holding the manhole plate in place, and, with full steam pressure on the boiler, the proper seating of the gasket was readily accomplished by blows from a heavy sledge delivered on the manhole frame on each side of the leak. The discovery of this ingenuous method was due to the fact that the manhole frames were of cast iron, were possessed of considerable weight and inertia, and exhibited their resistance to sudden motion by cracking and breaking in the places struck. In some plants, sledge hammers, like ferocious dogs, should be chained where they can do no harm

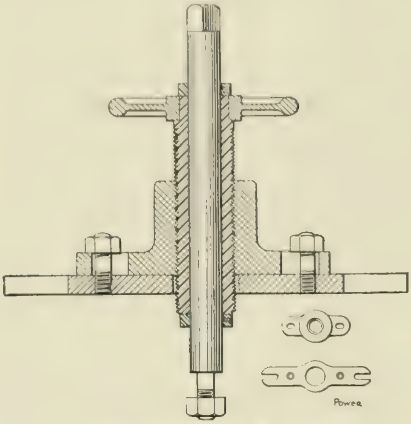
J. E. Terman.

Hartford, Conn.

⁂

Valve-Reseating Tool

The valves and valve seats of a pump working against high pressure, in a short time, will become so badly cut by the water wire drawing through them that a large percentage of the water will slip back through the valves and around the plungers. This slippage may vary from 5 per cent. with the pump in good order to 85 per cent. with the pump in bad condition. This slippage reduces the capacity of the pump in proportion to the amount of slip, and causes it to require more steam and time to deliver a given amount of water. The valves may be taken out and placed in the lathe to be refaced. The valve seats may be treated the same way, but as they are either pressed or screwed into the seats tightly they will be sprung out of shape in removing them, and, after being faced up true in this condition, will be sprung again in replacing them. For this reason they should be refaced in place.



Valve-Reseating Machine

It was decided to reface a number of seats in place, and the machine shown was constructed for use in any of several pumps, some of which were of the flat-valve type, and some of the pot-valve type with valve seats on an angle of 45 deg. The tool has a spindle, which is free to rotate but is held by collars against endwise displacement, in an adjustable threaded quill. Several cutters of different sizes were purchased to fit the valve seats of the various pumps. The body of the machine fits the seat on the pot-valve pumps, the bolt holes taking the valve-cap studs. The studs in the extension bar also fit these holes. When the machine is used on flat seats the valve-chamber studs are used to hold it solid, and a block under either end holds it high enough above the valve seat to allow the cutters to turn. After the valve and seats have been refaced those having brass valves are ground in with oil and emery or powdered glass, and those having hard-rubber disks are scraped to a good fit.

The valves are turned in grinding by means of a carpenter's brace. Some of them have a screwdriver slot in the top of the solid stem, and others are turned by means of a taper, one end of which fits the brace. Only a little time is required to grind them to a tight seat.

The valves should be examined at regular intervals and it is a good idea to have a steam gage connected to the steam chest of the pump. When the valves get in bad condition a higher steam pressure will be required to supply a given amount of water, which signifies that the valves need attention.

The blowoff valves on the boilers of this plant were of the angle type, with renewable disks faced with babbitt metal or soft composition, which could be changed by taking out two bolts and removing the bonnet. Several spare disks were kept on hand, and refaced in the lathe or rebabbitted when required. When the seats became worn, which could be easily detected as the ends of the blowoff pipes were exposed, they were refaced with this reseating machine. When they became worn down until they could be reseated no longer they were replaced.

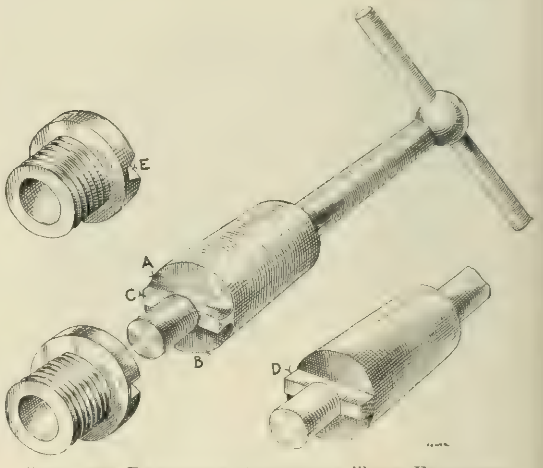
J. C. Hawkins.

Hyattsville, Md.

⁂

Condenser-Ferrule Tool

An efficient tool for removing condenser ferrules is shown in the accompanying illustration. It is made of a solid piece of steel, milled as shown at *A* and *B*, so that the end of the tool will have sharp gripping edges with which to turn the ferrule when fitted in the ferrule slot. The tool, when properly tempered, will last for years. Particular attention should be given to the shape of the driver end shown at *C*, which is of most importance.



Tool for Removing Condenser-Tube Ferrules, Note the Shape of the Turning Lug

I have used the same tool for several months on ferrules with the slots as badly worn as that shown at *E*, with the ordinary tool, *D*. When the edges start to wear out, the tool is useless, because it will not grip in the slot unless a heavy pressure is used to hold the tool in place. The ferrule is generally ruined in the process.

The tool, illustrated herewith, overcomes this trouble, due to the peculiar shape of the working end, which fits in the base of the slot in the ferrule and the turning power is applied to the base of the slot and not at the outer edge. There is no ferrule too difficult to remove and there should be no leaky tube, as every ferrule can be put up tight against the packing and a tight joint made without injuring the slot.

J. A. Lucas.

New York City.

Calking Tool in Blowoff Valve

The account of a fouled blowoff valve as related in a recent issue interested me as I had a similar experience.

Our boilers are blown down every six hours. Each blowoff line to each boiler is provided with a plug cock and an asbestos-packed gate valve. After blowing down one boiler I tried to close the gate valve but failed. Fortunately, the plug cock could be closed and the boiler left in service for two days.

A calking tool was found in the valve, notwithstanding that the boilers were inspected regularly and thoroughly, and the short vertical pipe to the horizontal line containing the valve and plug given special attention. The tool must have been in the pipe many months, having got as fas as the elbow and remained there until corroded enough to allow it to make the turn.

Claude R. Van Keuren.

Famoso, Calif.

Proper Location for Vacuum Breaker

A mistake is frequently made in the method of applying a vacuum breaker to a jet condenser, especially in installations where a dry vacuum pump is used. The purpose of the vacuum breaker is to prevent the condensing water from flooding the exhaust in the event of failures of the auxiliary apparatus. In many instances the breaker is placed upon the condenser, and when it operates the air forces the water into the suction pipe of the vacuum pump, wrecking it.

The proper way to install a vacuum-breaking device on such condensing units is to place the float chamber as close as possible to the regular water level, then place the vacuum-breaking valve in the suction of the pump as near as possible to the cylinder, connecting the mechanism together by a light cable.

The operation of the device should be tested each time the unit is stopped by shutting down all auxiliary apparatus, leaving the injection or condensing water flowing into the condenser until the float operates the valve.

John F. Hurst.

Louisville, Ky.

High-Power Hydraulic Turbines

In an article on the Tallulah Falls hydro-electric development, in the Jan. 27 issue of Power, the statement is made that the turbines are among the highest powered in the world, which is correct. But in the synopsis of the article they are declared to be the highest powered in the United States. This latter statement is incorrect.

The turbines in question are said to have developed 18,600 hp. under test, although rated at 16,000 hp. While this places them among the most powerful, they do not take precedence over all others in that respect. The most powerful turbine, unit so far built, will develop 25,000 hp. with the maximum gate opening. This unit, however, consists of two runners upon the one shaft, discharging into a common draft tube. It was built by the I. P. Morris Co. for the Washington Water Power Co.

The greatest power developed by a single runner is 22,500 hp. This wheel was built by the Allis-Chalmers Co. for the Pacific Coast Power Co. However, it has a double discharge. The largest single discharge turbines, of the type of the Tallalah Falls wheels, are of 20,000 hp. The Pelton Water Wheel Co. are building a reaction turbine of that type and size and the I. P. Morris Co. are building several of them.

R. L. Daugherty.

Ithaca, N. Y.

Log for Absorption Plant

As I have never seen an absorption-plant log published in Power, the accompanying form may be the means of drawing discussion regarding the different methods of recording the performance of this type of plant. Only a small amount of ice is made in the plant, the brine being used principally for cooling drinking water and the laboratories in which engineering and scientific instruments are tested.

REFRIGERATING ROOM LOG

Date .... 191...

TIME	TEMPERATURE DEG. F.				PRESSURES							PUMP DISPLACEMENTS		BRINE METER READINGS
	BRINE		WATER		GENERATOR		COOLER	ABSORBER	BOILER	BRINE	CITY WATER	AMMONIA	BRINE	
	COOLER INLET	COOLER OUTLET	INLET	RECT. OUTLET	STEAM	AMMONIA								
Night 12:30														
1:30														
2:30														
3:30														
4:30														
5:30														
6:30														
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8:30														
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REMARKS

________ ENGINEER ________ TO ________
________ ENGINEER ________ TO ________
________ ENGINEER ________ TO ________

Power

Except when a special test is being run, making continuous operation necessary for several days, the plant is run during the night shift, four or five hours each night being long enough to take care of the increase of brine temperature brought about during the day.

H. G. Gibson.

Washington, D. C.

Inquiries of General Interest

Reversed Polarity of Exciter—How may the polarity of an exciter which has become reversed be corrected?

D. G.

By lifting the brushes and then bringing leads over from another machine, or by closing the main switch on the machine itself so as to put a current through the field in the right direction.

Turning Size for Piston Ring—To what diameter should a piston ring be turned before being cut for a 14-in. diameter steam-engine cylinder?

M. O. D.

The ring should be turned off to a diameter of 14¼ in. and then have enough cut out of it to be sprung to the diameter of the cylinder.

Blackened Commutator Bar—If a commutator bar of a direct-current motor has become black, what does it indicate?

A. H.

That there is a short-circuit between commutator bars, or an open circuit in the armature, or a rough spot in the commutator, or that there is a loose commutator segment. If the blackening of the bar is due to an open circuit, there will be a vicious spark whenever the bar passes the brushes.

Expansion of Steam Pipe—If a steam pipe is 200 ft. long when put together at a temperature of 60 deg. F., what would be its total expansion in length when heated to a temperature of 300 deg. F.?

J. S. H.

For each degree Fahrenheit increase of temperature, iron or steel steam pipe expands about 0.0000065 times its length, hence by raising the temperature of 200 ft. of pipe from 60 to 300 deg. F. the increase of temperature being

$$300 - 60 = 240 \text{ deg. F.},$$

the expansion in length would be

$$240 \times 0.0000065 \times 200 = 0.312 \text{ ft., or practically } 3\tfrac{3}{4} \text{ in.}$$

Lift of Pump—If the steam pressure on a pump is only sufficient to force the discharge through a vertical pipe 80 ft. above the center of the pump-suction inlet, when the pump is supplied with water under only enough head to fill the pump, how high would the same steam pressure raise the water if the pump had to take its supply by a suction lift of 20 ft. below the center of the pump suction?

H. A. G.

Allowing the same loss of head from friction per foot of suction as per foot of discharge pipe, and assuming the suction pipe to be vertical, the net lift would be the same in each case and with 20-ft. suction lift the pump would raise the water

$$80 - 20 = 60 \text{ ft.}$$

above the center of the pump-suction inlet.

Pumpage of Oil vs. Pumpage of Water—If a given horsepower is required to pump 1500 bbl. of water per hour to a given height, then, neglecting any difference in pipe friction, how many barrels of oil with a specific gravity of 12 to 14 Bé. will be raised per hour through the same height by the same pump using the same power?

I. D. H.

The specific gravity of liquids lighter than water is found, from degrees Baumé, by the formula

$$\text{Specific gravity} = 140 \div (130 + \text{deg. Bé.}),$$

and taking the average as 13 deg. Bé., the average specific gravity of the oil would be

$$\text{Specific gravity} = 140 \div (130 + 13 \text{ deg. Bé.}),$$

or

$$\frac{140}{143} = 0.979,$$

therefore, the quantity of oil which could be pumped per hour would be:

$$\frac{1500}{0.979} = 1532.17 \text{ bbl.}$$

Transmissive Power of Belt—What horsepower can be transmitted by an open 10-in. single leather belt from a 40-in diameter × 12-in face pulley running 225 r.p.m. to a 30-in diameter × 12 in face receiving pulley, the shafts on which the pulleys are mounted being on the same level and about 15 ft between centers?

F. B.

Under ordinary conditions of belt tension and friction between leather belts and cast-iron pulleys, it is practicable, with single leather belts, to allow a transmitting capacity of 1 hp per inch in width of open-belt wrapping on a 30-in diameter iron pulley running 100 r.p.m., i.e., with a peripheral speed of 785.4 ft. per min., and to assume that for different widths and peripheral speeds the power-transmitting capacity is in proportion. As the peripheral speeds of the pulleys will be directly in proportion to their diameters and speed, then for the example quoted, viz., for a 10-in. single belt wrapping over a 40-in. diameter pulley which runs at 225 r.p.m. the ordinary power-transmitting capacity would be

$$\frac{40 \times 225}{30 \times 100} \times 10 = 30 \text{ hp.}$$

Expenditure of Heat by Friction—Give a formula for the expenditure of heat in British thermal units required for overcoming the friction of one solid body sliding or rubbing over another?

R. L. Y.

The work performed in overcoming frictional resistance, expressed in foot-pounds, will be the total pressure in pounds with which the rubbing surfaces are brought together × the coefficient of friction between the bodies × the distance which one body slides over the other, and as 778 ft.-lb. of work is equivalent to 1 B.t.u., then if

H = Heat expended in British thermal units;
W = Weight or pressure in pounds with which the bodies are brought together;
C = Coefficient of friction for the conditions;
F = Space through which the sliding takes place;

then

$$H = \frac{W \times C \times F}{778}$$

Velocity of Pump Discharge—With a duplex pump having water cylinders fitted with pistons of 4-in. diameter by 6-in. stroke, and each piston making 100 single strokes per minute, what would be the velocity of the discharge in a 2-in. discharge line working against 80 lb. pressure per square inch?

C. O.

The area of a 4-in. diameter piston being 12.566 sq.in., with 4-in. stroke the displacement per stroke in the head end of each cylinder would be

$$12.566 \times 6 = 75.396 \text{ cu.in.}$$

Allowing that the piston rods are 1⅛-in. diameter, the cross-sectional area of each rod would be 0.994 sq.in., reducing the stuffing-box side of each piston to an effective area of

$$12.566 - 0.994 = 11.572 \text{ sq.in.},$$

and the displacement per stroke in the stuffing-box end of the cylinder would be

$$11.572 \times 6 = 69.432 \text{ cu.in.}$$

As for each piston there would be 50 strokes of 75.396 cu.in. and 50 strokes of 69.432-cu.in. displacement per minute, then the total displacement of both pistons would amount to

$$50 \times (75.396 + 64.396) \times 2 = 14{,}482.8 \text{ cu.in. per min.}$$

and allowing 10 per cent. slippage the actual discharge would be 90 per cent. of 14,482.3 = 13,034.52 cu.in. per min.

The cross-sectional area of a 2-in. diameter pipe being 3.1416 sq.in., then when discharged through a 2-in. pipe the water would have a velocity of

$$\frac{13{,}034.52}{3.1416 \times 12 \times 60} = 5.76 \text{ ft. per sec.}$$

Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.

Engineers' Study Course

Curve Plotting—I

In general, curve plotting embraces the representation of numbers and equations by the relation of points and lines to base lines or a point. In this idea there should be nothing new to the engineer. He is used to looking at the charts of his CO_2 recorder, where varying percentages of CO_2 are represented by lines of varying length, or at the reports from his recording pyrometers and thermometers, or from his recording pressure gages, where variation in temperature and pressure are represented by differences in the distances of lines from a point at the center of the chart.

The utility of such charts is obvious from this use. The rise and fall of temperature are much more easily seen In the kinks of the recording gage's curves, than they would be from looking at a number of readings.

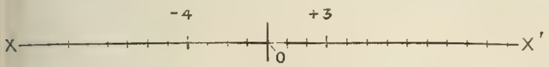

FIG. 1

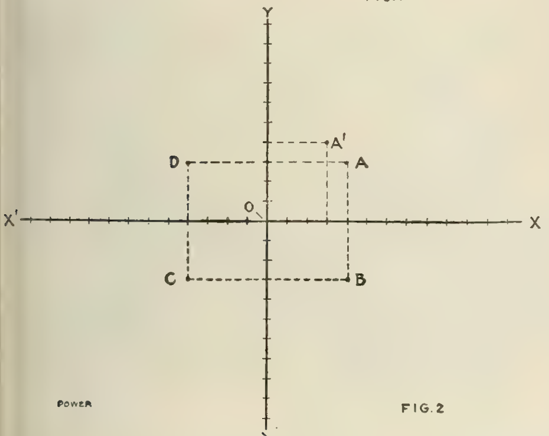

FIG. 2

The general method for the representation of numbers by lines we owe to the eminent French mathematician, Descartes. Imagine a line $X'OX$, Fig. 1, divided into qual spaces. We will call each space one unit, and will all those to the right of point O plus, and those to the eft of point O minus. Then if $x = +3$, we count out to the right three spaces. If $x = -4$, we count ut to the left four spaces. The + and — signs can be regarded in the same way as though one were told a house was at 1234 North Main or 1234 South Main St. It would make a difference which direction he started in, nd only that. There would be just as many blocks to walk.

Or, to take another illustration, we may say it is 68 eg. or —3 deg. this morning, basing this on the distance column of mercury is above or below a fixed point on a lass tube.

For most problems it is usual to have two lines along which we can measure. These lines we usually draw, for convenience, at right angles to each other, and call them $X'OX$ (known as the axis of X) and $Y'OY$ (the axis of Y)*. There is no absolute right or wrong about this. It is simply better if everybody agrees to draw $X'OX$ horizontal, and $Y'OY$ vertical. Then no long explanations are necessary—when one says the axis of X it is known immediately what is meant.

So, too, it has been agreed to call all distances to the right of O plus; all to the left minus; and all distances above O plus; and all below O minus (just as with sines and cosines in trigonometry).

We also agree, for convenience, that, given our axes of reference, and our scale, measured on both lines, see Fig. 2, we will always give the position of a point by the distances from the axes, and always name the x value first, the y value second. Thus, when we wish to speak of a point four spaces (its x value) from $Y'OY$ and three spaces (its y value) from $X'OX$, we say it is the point 4, 3, and to find it we measure an x out four spaces along the x axis to the right, then a y up three spaces, that is, parallel to the y axis.

Similarly, the point B is $+4, -3$; the point C is $-4, -3$; point D is $-4, +3$. (Work these out carefully, and make sure that the meaning of these signs is understood in each case.) We have seen that point A is the point 4, 3. The point 3, 4, would be a different thing. We would then count three to the right, and four up, and end at a point A' (Fig. 2). Try it.

To use a familiar analogy, we may imagine a rectangular room, square with the points of the compass. Were anyone to tell anyone else that he wanted a point marked out from the south wall and from the east, there would be no question what was wanted. So, too, after knowing the scale adopted, it is easily determined what point is meant if one says the point 4, 3; that is, x, the distance from the y wall is four, and y, the distance from the x wall, is three. We then measure these distances and find the point.

It is then possible, in this way, to represent any two numbers by a point, or conversely, to represent any point by two numbers, its coördinates. The x coördinate is called the abscissa of the point, the y coördinate is termed the ordinate. This again is a mere matter of definition.

For convenience, we usually find our points, and trace our lines, on paper that already comes ruled in squares, called "coördinate," or "cross-section" paper. The engineer is probably already familiar with such paper.

The indicator diagram is a familiar illustration of curve plotting to the engineer. In this case there are two variables, pressure, y, the ordinate; inches of stroke, x, the abscissa.

Another illustration which the engineer might use would be a chart on which is kept each day the number of tons of coal used. The abscissas would be 1, 2, 3, 4 days, the ordinates the number of tons, shown as a straight line extending up from XOX', or as a point on the paper.

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*They are sometimes known as the axes of reference.

One particular reason for choosing this last illustration is to point out the essential difference which exists between a line connecting the points which show coal consumption, and the line on an indicator card. The line on the latter is a continuous one, and it is fair at any point on the stroke to point to the corresponding pressure and say, just at this time the pressure was 132 lb. However, if on the sixteenth, one burned 26 tons of coal, and on the seventeenth, 29½ tons, one cannot point along the line connecting these points (if he has drawn it), and say, at midnight on the sixteenth, we were burning at the rate of 27¾ tons. It may be true, but he doesn't know it.

In the indicator card, the lines are true mathematical lines, each point of which represents a definite pressure-distance relation. In the tons of coal diagram, each point represents an isolated, single fact, and the lines drawn between these points for convenience do not represent, in their intermediate points, any physical facts. In using lines in such diagrams, this point must always be considered. The above is an almost self-evident matter. There are times when the point is not obvious. There is probably no error which more often spoils otherwise good reasoning than does that of imagining that lines joining points, drawn for convenience only, have a physical meaning at intermediate points. They have not. The meaning is in the points, the lines are only good to enable the eye quickly to see the change of direction from point to point.

We have, then, in this paper, seen that any point can represent two numbers; that any two numbers, representing two mutually changing variables, can be represented by a point; and that there are certain conveniences obtained in such representation, this point being drawn from daily experience. In the next lesson we shall take up the representation of equations by lines.

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Recent Court Decisions

Digested by A. L. H. STREET

When Power Machinery Does Not Become Part of Realty—Power machinery, although firmly affixed to real estate, will retain its character as personal property, so as to entitle the seller to reclaim it under a contract reserving title until payment of the purchase price, as against the buyer or a person who took a mortgage before the machinery was bought, even though the conditional sale contract has not been recorded. (New York Supreme Court, Appellate Division, Fourth Department; Ratchford vs. Cayuga County Cold Storage & Warehouse Company; 145 "New York Supplement" 83.)

Waiver of Delay on Delivering Coal—When a contract to sell coal requires delivery by the seller by a certain time, the buyer does not waive a claim for damages resulting from a delay in delivery by the mere fact of accepting delivery after the contract date; the acceptance merely waives any right to rescind the contract on account of the delay. (New York Supreme Court, Appellate Term, First Department; Molin vs. New York & Pennsylvania Smokeless Coal Company; 145 "New York Supplement" 116.)

Rights of Appropriators of Waters of Stream—The legal right of one who owns water rights in a stream by appropriation to acquire additional rights from other persons, and to change the point of diversion "is subject to the important qualification that the change of use or of the point of diversion must not be permitted to injuriously affect rights which have been lawfully acquired subsequent to the appropriation" by others. (United States District Court, Eastern District of Washington; United States vs. Union Gap Irrigation Company; 209 "Federal Reporter" 274.)

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

A Western "genius" is devising a plan to raise the "Titanic" by means of huge magnets. What he will probably raise won't need magnets—a storm of criticism will be about all.

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In recording a Magdalena, N. M., gas-plant explosion, in which Hen Ellis and Joe Epple were injured, the El Paso "Herald" says a Bible class has been organized at the Methodist church. Sounds like a new variation of the "safety first!" idea.

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There's nothing craven about Chief Engineer Craven; he isn't even afraid to accept $20,000 a year from the New York Public Service Commission. Looks like the engineer is coming to his own. We really need other than lawyers to straighten out our business tangles, and usually an engineer can do the straightening if he's adequately paid for that same.

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"Bananas and Tomatoes In the Canaries."—Daily Consular Report.

Those wise chaps who are helping the egrets figuratively to keep their shirts on came near being asked to extend their activities to the canaries, but on reading the article we find that bananas and tomatoes are merely products of the Canary Archipelago.

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WANTED: AN AUTOMATIC STOKER

Wife of Smoke Inspector—"My goodness, John, how in the world do you ever hold your position?

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Let it snow! What do we care. But, it costs New York City a million dollars each winter to clean the streets. Thanks to the suggestion of a correspondent to the New York "Times," it may now snow like ——— well, like it did Saturday, Feb. 14, and it won't cost the City a cent. Here's how he is going to do it.

"The average frontage of stores and residences is, we will say, 25 ft. On a 40-ft. street, with a 15-ft. sidewalk, there would be an area of about 900 sq.ft. covered with snow, say to the depth of 6 in. each side of the street. This makes about 450 cu.ft. of loose snow. If this bulk were taken into the basements of each building and placed in a box till it melted the space required would not be great.

"An arrangement could be made at small cost to construct a kind of receptacle or hopper to receive the snow, and this could be attached by a pipe to any sink or drain pipe so as to carry off the water as the snow melted. A lighted gas jet might be arranged so as to play upon the hopper, and thus melt its contents in a few minutes."

Of course, if the basement or tank is below the sewer level, one could install a small boiler and pump or an air compressor and ejector to handle the water. In summer the tank would make a good swimming pool, the snow chute serving as a slide. With proper accessories the tank might make a good rat trap.

Selecting a Prime Mover*

By H. E. Longwell

SYNOPSIS—A typical analysis of the problem of selecting the best type of prime mover for the generation of power. Specifically it refers to the problem in connection with the electro-chemical industries and more particularly the electrolytic refining of copper. By a process of elimination it is shown that, under the assumed onditions, first, a steam plant is to be preferred to a gas lant, then that, of the steam plants, attractive as is the reciprocating engine-turbine combination, it cannot ompete with the turbine alone, and finally that a turbine with geared drive to a direct-current generator has dvantages over an alternating-current, turbo-generator unit in combination with a rotary converter.

⁂

If one is designing a power plant, he must not become so bsessed with the question of mere steam economy that he vill spend a dollar to save ten cents worth of steam, or en cents to save some steam that costs nothing at all.

It is not unusual to find intelligent people who see the ower problem with such a distorted perspective, that the ingle item of the steam consumption of the prime mover ides everything else. I recall two cases that were especially ypical; one a wagon works in the West and the other a extile mill in New England. Both were using single-valve igh-speed steam engines of a type that I regard with respect nd affection, but which has been frequently and slanderously haracterized as a "steam eater."

WHEN STEAM SAVING IS NOT ECONOMY

The manager of the wagon works admitted that he was etting reliable operation from his engine with a minimum xpense for upkeep. However, someone told him that Cor-iss engines would do the work with 25 per cent. less steam nd he was appalled by the ruinous waste. Now this work in-ludes some acres of dry kilns which require more steam than he total exhaust of the engine; in fact, it was practically im-ossible to detect any measurable difference between the uel consumption on Sunday, when the engine was not run-ing, and any regular working day. The fuel was all refuse rom the wood-working machines and there was always a urplus which had to be burned in a destructor. By patient easoning with the manager, he was able to see that if saving ll of the steam used by the engine did not effect any notice-ble reduction in the total fuel consumption, it would be opeless to expect any economic benefits to accrue from a aving of 25 per cent. of it; and finally it dawned upon him hat, even if he could save a measurable quantity of fuel by nstalling another engine, his only return for the increased nvestment would be the joy of burning up his savings in e refuse destructor.

The textile mill mentioned engaged a new superintend-nt and he could see nothing ahead but bankruptcy, unless e wasteful high-speed engines were replaced by a com-ound condensing engine. In this mill sundry washing and ying operations used up all the exhaust of the engine and me live steam besides. Before committing any blunders, e new superintendent was deftly and skilfully assisted to understanding of one fundamental principle of power ant economics, to wit: If all of the exhaust steam from engine is required for some useful purpose, that engine is rnishing power with an efficiency of 100 per cent., and any penditure with the object of bettering that efficiency is t likely to be a temptingly profitable investment.

I have put some emphasis on the policy of attaching too uch importance to the question of mere fuel economy in a wer plant, because I think I detect a little tendency in is direction in the presentation of the problem that has en submitted as a foundation for this discussion. Sundry timates are submitted as representing the probable costs steam and electrical energy exclusive of administra-n, taxes, depreciation, and electric charges.

CONSIDERATIONS NOT TO BE OVERLOOKED

The items of interest, taxes, insurance and depreciation, or to speak more exactly, amortization, are too important to be ignored. These so-called fixed charges or investment costs are in general, greater in amount than the total cost of labor, operating supplies and maintenance. They are especially significant in that they measure the cost of fuel economy.

WHY THE GAS ENGINE IS NOT ATTRACTIVE IN THE ELECTROLYTIC REFINING PLANT

To illustrate, let us consider the probable comparative performances of a high-grade steam turbine plant and a gas engine and producer plant consisting of several 1500-kw. generating units. The electrolytic refining industry offers any investment in the interest of economy an unusually favorable opportunity to "make good," because it is permitted to work 8760 hours per annum.

Assuming the fuel to be the highest grade of bituminous or semi-bituminous coal, having a calorific value of 14,500 B.t.u. per pound, the gas engine and producer plant would, under test conditions, effect the saving of one-half pound of coal per kilowatt-hour over the turbine plant or say, two tons per annum. If the coal costs as much as $3 per ton, this would mean a saving of $6 per kilowatt-year.

The gas engine and producer plant will cost about $50 per kilowatt more than the steam turbine plant and the question arises as to whether it is worth while to invest $50 in plant to save $6 a year.

Naturally, there will be differences of opinion as to what would constitute an attractive return on this extra investment. I should want 6 per cent. for interest, 1 per cent. for taxes, 1 per cent. for insurance, and 2 per cent. for maintenance, having due regard to the appalling speed with which new things in engineering become old, I shouldn't feel comfortable unless I had a sinking fund of 8 per cent. to provide for the safe return of my capital, for some of these items amount to 18 per cent. In my opinion the gross return should be not less than 20 per cent. per annum, so that this saving of $6 per kilowatt-year, would be too expensive if it required an extra investment of more than $30 per kilowatt in plant equipment.

In thus calling attention to the importance of investment for fixed charges as a factor in the cost of power, I am only touching superficially the doctrine, that has been ably and vigorously preached and assiduously practiced by Henry G. Stott.

The determination of the true cost of electrical energy is a large subject and those interested in it will profit by reading a paper entitled "Standardization of Methods for Determining and Comparing Power Cost in Steam Plants," which was presented jointly by Mr. Stott and W. F. Gorsuch at the June, 1913, meeting of the American Institute of Electrical Engineers and which is published in the May 1913, issue of the proceedings of that Society. This paper is particularly happy in its treatment of investment costs.

With respect to the type of power plant best suited for the electrolytic refining of copper, we may safely eliminate gas engine equipment from serious consideration.

THE ADVANTAGES OF STEAM IN THIS PROBLEM

The plant will naturally be located where there is abundant water available for condensing purposes, and where the cost of fuel is reasonable. In other words, we may choose a location where the conditions enable a steam plant to display its best economy. Under these conditions, the gas engine plant would be a doubtful investment, even were there no especial reason why it is not desirable for this particular class of work.

There appears to be one reason why the proposition is peculiarly one for a steam plant.

According to Mr. Addick's statement of the problem, if live steam were used for heating the electrolyte, the total steam from the boilers would be used as follows:

One-half for electric power generation, one-fourth for steam driven auxiliaries, and one-fourth for heating the electrolyte. Steam-driven auxiliaries are not, as a rule, so efficient that they abstract any serious amount of heat from the steam passing through them so that for heating the electrolyte the exhaust from these auxiliaries would be practically as effective as an equal quantity of boiler steam. Therefore, the boiler steam required for auxiliaries and for heating the electrolyte would be approximately 50 per cent.

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*From a paper entitled "The Power Problem in the Elec-olytic Deposition of Metals," presented at a joint meeting the New York members of the American Society of Me-anical Engineers, the American Institute of Electrical Engi-ers and the American Electrochemical Society, Jan. 9, 1914. ported in "Power," Jan. 27, 1914, page 146.

of the amount required for generating the electric current.

I am informed that in a plant having an output of 500 tons of refined copper per day, the waste heat boilers connected to the reverberatory furnaces forming a part of such a plant, should be capable of supplying 40,000 lb. of steam per hour. This is somewhat over 10 per cent of the steam required by the main generating unit or practically enough to operate all of the auxiliaries that would usually be run by independent steam motors in a steam-driven plant, and the exhaust from these auxiliaries would take care of the heating of the electrolyte.

The quantity of steam is too important to ignore and even though gas-engine-driven main generating units were installed, it would be necessary to make use of this steam from the waste heat boilers. The practical difficulty arises from the fact that while the tanks are operated continuously, it is not usual to run the furnaces on Sunday, consequently it would be necessary to have a considerable boiler plant in reserve to be operated only one day in each week to tide the plant over Sunday, and so, even if there were no question as to the commercial economy of a gas engine and producer plant, as a general proposition, this one practical operating condition would be sufficient to rob it of all of its theoretical advantages.

In a steam plant the regular boiler equipment is so flexible that it will readily take care of the fluctuation in the output of the waste heat boilers. Since with modern mechanical stokers it is not unusual to force boilers to 200 and 300 per cent. of their normal rating, it is evident that no decidedly disproportionate boiler equipment would be required to carry the plant over the weekly interval in which the waste heat boilers are out of commission.

THE ENGINE-TURBINE COMBINATION

The combination of a compound reciprocating engine exhausting into a low-pressure condensing turbine, looks, on first consideration, to be inviting, since it is generally admitted that, between the limits of the usual boiler pressure and atmospheric exhaust pressure, a reciprocating engine is usually more efficient than it is customary to make the portion of a complete expansion turbine that takes care of this part of the pressure range. While the superior fuel economy of this combination seems apparent from purely theoretical consideration, there is comparatively little available information regarding its amount in actual figures.

It is not denied that this combination has its legitimate uses, but it is most certain that mature judgment is required for determining the conditions under which it may be recommended, and it is equally certain that the combination has been installed in a number of instances in which its use was decidedly ill-advised.

Admitting the hypothetical economy of the combination, let us consider the features that tend to offset this advantage.

We have, first, increased the initial cost. A low-pressure turbine will in many instances cost 75 to 80 per cent. more per kilowatt than a complete expansion turbine. That this is reasonable may be seen readily by an inspection of a sectional view through a typical expansion steam turbine of the Parsons type. Let us assume that the capacity of this machine is 3000 kw. What must we do to break this 3000-kw. turbine into a low-pressure turbine of half this capacity? We simply cut out a small portion, and increase the inlet opening some six or eight times. But it does not require any unusual qualification to enable one to see that the part eliminated does not, by any means, represent one-half of the cost of the 3000-kw. machine. Neither would anyone expect to purchase 1500 kw. capacity in a reciprocating engine for the cost of the section that has been eliminated from the complete expansion turbine. Again, no one would claim that the expense of installing the combination unit would be less than twice that of installing the single complete expansion unit. And no one would be hardy enough to suggest that the charges for attendance, maintenance and operating supplies would be approximately equal for the two units.

There are doubtless cases in which the possibility of conserving reciprocating engines already in use would justify this combination type of unit, but in a plant that is new throughout, its desirability is, to say the least, highly problematical.

As far as actual authoritative figures giving the comparative power cost for the two types of units are concerned, Mr. Stott could give us these if he would. The most important installation of combination units in the world was carried out under his direction. He had the justification of conserving valuable reciprocating engine equipment, which was in excellent physical condition, and there can be no question but that the best possible engineering judgment was exercised in designing and executing the project. I am confident that Mr. Stott has accurate and comprehensive costs o electrical energy as generated by this plant and that thes costs represent the utmost possibilities of this type of unit

If Mr. Stott would be willing to say whether or not in a absolutely new plant he would seriously contemplate the installation of combination reciprocating engines and low pressure turbine units, such a pronouncement would b more convincing than volumes of argument based purely o theoretical grounds.

WHEREIN THE TURBINE ALONE HAS THE ADVANTAG

As regards the comparative merits of compound and triple expansion reciprocating engines and turbines as prime movers, the trend of general practice in power plant design shows conclusively that the turbine has the advantage. I has economic possibilities at least equal to those of the reciprocating engine, and markedly better when working with the high vacuum obtainable with the newer types of condensing apparatus and the copious supply of cooling wate that is invariably found in places that would be regarde as favorable for electrolytic copper refining plants.

I speak of the economic possibilities of a certain type o prime mover rather than of its inherent economy, because th latter is inseparably associated with the type. A prim mover is not economical simply because it is a compoun engine, a triple-expansion engine or a turbine, but becaus it is economical by design. There are hundreds of triple-expansion engines that are less economical than some compound engines. In fact, I am not sure that there are authentic records of triple-expansion engines which show sufficient improvement over the economic results of the bes examples of two-cylinder compound engines to justify th added complication and expense of the third cylinder an its connection.

It is possible to design a turbine that will be less economical than a very ordinary multiple expansion reciprocatin engine. On the other hand, turbines are built that unde suitable operating conditions give economical results tha cannot be equaled by the reciprocating engines of an type, however skillfully designed, if operated under th same conditions.

The advocates of the turbine can afford to be unnecessarily modest and claim no more than equality with othe types of prime movers as regards steam economy, for ther remain still the unquestioned advantages of lesser cost an smaller installation expenses.

THE GEARED-TURBINE DIRECT-CURRENT UNIT

For some years the turbine was at a disadvantage i plants in which it was desirable to generate direct curren for the reason that the rotative speed of an efficient stea turbine and the rotative speed of a reliable, efficient direct current generator are not compatible. This disability ha happily been removed by the development of a reliable transmission gear which allows any reasonable speed ratio between the turbine and the generator. This gearing has a efficiency of over 98 per cent. and has been in public us long enough to demonstrate that, in point of reliability an durability, it is at least on a par with any other kind of apparatus forming a part of an electric power plant.

While the geared direct-current unit costs more than a alternating-current turbo-generator unit of the same capacity, it is cheaper and somewhat more efficient than the combination of an alternating current unit and a rotary converter.

I am not in possession of reliable costs for compound reciprocating engine-driven units, but commercial experienc indicates that the geared turbine-driven unit has an advantage as regards price f.o.b. at the factory. With spac and installation costs added, the advantage is obviousl more marked.

Figures purporting to give probable plant and unit powe costs are as a rule unsatisfactory because they are affecte by too many variable factors. As regards plant costs, i might be said that, depending on the expensiveness, or simplicity, of one's architectural taste, his luck in selecting contractor, his resourcefulness as a designer, his finesse a a buyer, the accessibility of the site selected, the state o the weather, and a lot of other things, he ought to be abl to build a really good turbine-driven plant of from 600 to 9000 kw. capacity for $75 per kilowatt, more or less.

As regards the cost of power, if one is satisfied with investment charges of 10½ per cent. per annum; if he can bu really good coal at not to exceed $3 per ton; if he is capable manager and a careful operator, and reasonabl economical, he ought, with a plant of this size, to be abl to produce a kilowatt-hour at the switchboard with substantially 100 per cent. load factor for 4.3 mills, also subject to the qualification "more or less."

Congress and Water-Power Development

Dam sites, rate regulation and other matters pertaining to the development and distribution of hydro-electric power are on the cards to stir up controversy before the end of the present session of Congress. Following the recommendation of Secretary Lane, of the Department of the Interior, that there should be a letting down of the fences around dam sites in the public domain so that power plants can be constructed, the House Committee on Interstate Commerce has appointed a special committee to wrestle with the problem of how the government may permit private enterprise to develop hydro-electric power without creating unrestricted private monopoly. This committee consists of Representatives Adamson, of Georgia, Stevens, of Minnesota and Copley, of Illinois.

Some idea of the proposed legislation is suggested in the annual report of Secretary Lane, who says pointblank that the government ought to construct power plants and develop and distribute the electric power itself, but that he is afraid public sentiment is not sufficiently developed to make such a policy immediately possible. In the meantime, and until Congress gets ready to appropriate the money to do this work, he thinks private companies ought to be allowed to lease dam sites and construct works, which the government may have the privilege of buying after twenty years, and which will revert to the government at the end of fifty or sixty years.

Secretary Lane asks Congress to provide $100,000,000 more for extending the government's irrigation plants and building new ones, and points out that the government should regard this only as a loan, to be repaid out of the increased values given the land by irrigation, and the returns from power plants developed in connection with irrigation reservoirs, which he would have the government construct and operate as part of the irrigation works. The problem of what value to place on power sites, the Secretary admits, is a puzzling one.

"The country," he says, "has been aroused too late to save the richest points of vantage. Private power companies hold the most accessible of these dam sites under rights of which they can never be deprived. So much more compelling the reason why we should not yield what remain unwisely. The temptation to grant generously without condition that which may be put to so beneficent a use must be resisted if we are not to meet with a spendthrift's fate. At the same time there must surely be a rational way by which capital may be brought into this public service. The present conditions of stagnation do no one any good. Within a generation I believe the people will be as alive to the value of public ownership of hydro-electric power plants as they are today to the value of municipally owned waterworks.

"How may the needed advantage be gained for the present and the needs of the future be cared for? This is the immediate problem. What may capital reasonably demand? A fair and attractive return upon its investment yearly and the full return of its capital. And what may the public reasonably require? Good service and fair rates. Who shall make these rates? Within the state they must be subject to state regulation; between the states, Federal authority must control. What return shall the Federal government have for its lands? My answer would be, no return whatever, provided the plant reverted to the government without cost at the end of fifty or sixty years, or so much of the plant as was based on the land itself and the improvements directly attached thereto such as reservoirs, dams, water rights and the rights-of-way. For the tangible property of the plant, such as the distributing system and machinery, the government might well agree to pay an appraised price so as to insure its being maintained and extended during the later years of the life of the franchise. The right to buy the complete plant at an appraised figure at any time after 20 years would be a further protection, and one not burdensome, while for better service it would seem advisable that all plants be encouraged to physically combine, just as our railroads are required to couple themselves into through routes and thus make their service continuous and interdependent; but they should not be allowed either to agree as to the rates or to merge their capitalization or their identity.

"Such a plan as is here suggested should be attractive to capital wherever there is bona-fide need for such water-power development, for it is definite in its terms and can be made a precise basis for capitalization. The term of the franchise would be long enough to permit of the amortization of the plant upon such a percentage as would lay no heavy burden upon each year's earnings. Where a reservoir site is also used for the storage of irrigation waters, the right to which attaches to certain lands which should enjoy that use forever, it could be provided that at the end of the franchise period the government would either turn over the plant to the water-users or the state or otherwise provide for its operation."

Senator George Norris, of Nebraska, announces that he will try to secure a vote in the Senate on his bill to begin the development of hydro-electric power in the Potomac River, just above Washington. He wants the government to build the plants and operate them, and supply current for public and private uses in the city.

It is estimated that within 15 miles of Washington, there can be developed about 25,000 hp. of electricity, by damming the Potomac at three points. This project for giving the National capital cheap light and power has been talked of occasionally for the last 20 years, but nothing has been done about it, while a private corporation, developing power from coal, has been and is selling electricity for house lighting at 10c. per kw.-hr. and for business and power for anything it can get.

The Norris bill proposes a dam and power plant at the Chain Bridge in the Potomac, to develop 15,000 hp.

Representative Rainey, of Illinois, wants Congress to investigate the affairs of the Keokuk & Hamilton Water Power Co., and its several subsidiary and associated corporations, which own the big dam across the Mississippi River at Des Moines Rapids, Ia. This company was given a grant of the dam site by Congress in 1901. Its dam is the biggest in the world, is said to have cost about $15,000,000; it is nearly two miles long, and now develops 150,000 hp. although the ultimate development will be 300,000 hp. The franchise was granted in perpetuity, and the company is unregulated, so far as its rates and financial operations are concerned, neither the Federal government nor the state exercising any regulatory power over it.

When the company's franchise was granted, it was promised that by the building of the dam, the navigation of the river would be improved and the nearby cities and industries would be given cheap current. It is charged now that neither promise has been kept. Instead of improving navigation, it is claimed by steamboat men that the manner in which the dam is operated makes the river at times unnavigable, and instead of cheaper power, the hydro-electric company is gobbling most of the older light and power companies in its territory, supplying power from the big dam, and charging about the same high rates the people have always paid.

There is a confusion of corporations in the handling of the electric current generated at the dam. While the dam was built for the Keokuk & Hamilton company, it seems, the company that generates hydro-electric power is the Mississippi River Power Co. This company sells electricity through a subsidiary corporation, the Mississippi River Power Distributing Co., which is said to take a profit of two mills per kw.-hr. A single contract provides for the sale of 60,000 hp., or one-fifth of the potential development, to the Union Electric Light & Power Co. and the United Railways Co., of St. Louis. This contract is made for 99 years, and the St. Louis companies pay about six mills per kw.-hr. This single contract gives the dam company an income of $1,080,000 a year, or practically enough to pay the interest on its bonds and preferred stock, leaving (with the exception of the small operating charge) the company the returns from four-fifths of the capacity of the dam as profit, to ultimately be distributed to the holders of the $16,000,000 of common stock, which seems to have been given as a bonus with the preferred stock and bonds.

The two St. Louis companies to which the dam company sells this power at six mills per kw.-hr. are controlled by the North American Co., which, in turn, owns a large amount of the stock of the Mississippi Power Co., so that, in effect, the dam company is selling power and light to the people of St. Louis, and charging practically the same prices that were charged before the dam was built. Although the company delivers power to the distributing companies at six mills per kw.-hr. it is said that the lowest rate of the distributing companies is 3c. per kw.-hr. while for general lighting the St. Louis rate is from 6 to 9c., about the same as it was before.

Bills have been introduced in Congress by three members from Missouri proposing reductions in electric rates for St. Louis. Other cities getting power from the big dam have fared no better. Mayor Abbott, of Quincy, Ill., says that in negotiating a new contract for street lighting with the local company, he was told that they cannot furnish light any cheaper, although they are now getting current from the big dam.

At Warsaw, Ill., power is sold to the city and to private consumers by the Keokuk Electric Co., a subsidiary of the

Mississippi River Power Co. Mayor Louis Lament makes the following significant statement of the situation in Warsaw:

"The commercial lighting rate was reduced by the new company entering the field, but, strange to say, the old company is offering better rates than the new, although the latter is connected with the Keokuk company, and the old company is producing current from coal. This reduction is not very much, and it is clearly evident that whichever company forces the other one out, will again charge the old rate."

A score of other cities adjacent to the big dam tell the same story of disappointed hopes of getting cheap light and power from the dam. Evidence is presented by Mr. Rainey to show that the men who control the dam and power development are in close combination with practically all the utility corporations in the territory reached by current from the Keokuk plant, and that instead of the cities and power consumers getting any benefit in lower prices from the development of this great water power, the whole benefit is going in profits to the promoters.

Representative Rainey and other members believe that Congress has the power to annul the franchise of the dam company or to amend it in almost any way, and they are planning a fight to get some share of the benefits from the big hydro-electric development for the public. The company, however, contends that Congress has no power to regulate it or to modify its franchise. It rather looks as though the effort to get lower rates now was like locking the stable door after the horse has been stolen.

Years ago the government undertook to build a dam on the Mississippi at Rock Island. It was never finished and a flood washed part of it away. Some congressmen are now urging legislation to permit the completion of this dam, and with it the construction of a power plant to supply current for the government arsenal at Rock Island. Congressman Tavenner, who is among those urging this plan, also wants the government to build an armor plate plant at Rock Island, and use the current generated at the dam in the manufacture of armor plate for Uncle Sam's war vessels.

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Mechanical Engineering Progress

At the recent convention of the Indiana Engineering Society, the committee on mechanical engineering, consisting of E. H. Ahara, C. B. Veal and J. D. Rigg, presented a report covering the whole field. The following two extracts are of most direct interest to POWER readers:

The internal-combustion engine has received much attention in the past year and is being gradually brought to greater perfection. In the stationary line many new designs are being brought out using the Diesel principle of constant pressure and injecting the oil, often low-grade, under pressure. This method is teaching us how to use crude oil advantageously and with great economy, thus conserving the supply of high-grade oils for use in the automobile engines. These latter are changed but little in the last year, except that a long stroke engine is now almost invariably used.

The latest design of producer-gas engine that has come to the public notice is one being developed for the Ford Motor Car Co.; a combination gas and steam engine, with two tandem cylinders on each side. Gas is to be used in two cylinders on one side, the cooling water from which is further heated from the waste gases in the exhaust and from the waste heat of the producers, before going to the boilers that supply steam to the two tandem steam cylinders on the opposite side. A large balance wheel is used to maintain steady operation. Greater economy is expected than has been heretofore attained by prime movers.

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Water Resources of Southern Rivers—Water-Supply Paper 307, recently issued by the Unitel States Geological Survey, contains records of the flow of rivers in the Arkansas, Yazoo and Red River basins, tributary to the lower Mississippi, during 1911. Thirty-one stations were maintained in the basins of these rivers during the year. The Arkansas River records cover the principal upland tributaries in Colorado, together with Canadian River in New Mexico and White River in Arkansas and Missouri. A copy of this report or of Water-Supply Paper 287, which covers similar work in 1910, may be obtained free on application to the Director of the Geological Survey, Washington, D. C.

BOOKS RECEIVED

FACTORY ORGANIZATION AND ADMINISTRATION. By Hugo Diemer. McGraw Hill Book Co., New York. Cloth, 378 pages, 6x9¼ in., 174 illustrations. Price $3.

ELEMENTARY MANUAL OF THE STEAM ENGINE. By Ernest V. Lallier. D. Von Nostrand Co., New York Cloth, 266 pages, 5¼x8 in.; 102 illustrations. Price $2.

MECHANICAL LABORATORY METHODS. By Julian C Smallwood. D. Van Nostrand Co., New York. Flexibl leather; 333 pages, 5x7½ in.; 95 illustrations. Price $2.50.

ELECTRIC LIGHT AND MOTOR WIRING. By George J Kirchgasser. Electroforce Publishing Co., Milwaukee, Wis. Flexible leather; 270 pages, 3x6 in.; 150 illustrations. Price $1.

Bulletin No. 58, issued by the Bureau of Mines, Department of the Interior, gives an account of the fuel briquetting investigations carried on from July 1904 to July 1912, by C. R. Wright. The bulletin contains 277 pages, 21 plates with figures, and may be had by addressing the bureau.

The sixth edition of the Electrical Blue Book, issued annually by the Electrical Review Publishing Co. of Chicago, is now in print. It contains a very complete list of approved electrical fittings with the names and addresses of the firms making them, besides 80 pages illustrating construction material. In an appendix are included the National Electric Code, illustrated and explained, and a compilation of useful information such as Wiring Calculations, Illumination Calculations, Treatment for Electric Shock, Rate Charts, Street Lighting Schedules, Motor Applications and Ground Detectors. The price is 25c.

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Explosion of a Compressed-Gas Cylinder on the "Mauretania"—Recently, a disastrous explosion occurred on board the Cunard liner "Mauretania." The vessel was lying in Canada Dry Dock undergoing engine repairs, which included the insertion of a number of blades in the high-pressure turbines. For this purpose an autogenous welding plant was being used, and it is stated that, without the slightest warning, a cylinder of compressed gas in connection with the plant burst, with terrible results to about a dozen men engaged in the room at the time, three being blown to pieces, and eight others injured, some of them so terribly that it is doubtful if they will survive. The cause of the explosion has not been ascertained, but will doubtless be inquired into at the inquest.—"Mechanical Engineer."

⁂

Wider Powers for West Virginia Commission—In a recent decision by the Supreme Court of Appeals of West Virginia against the United Fuel Gas Co., which asked that an order of the Public Service Commission be suspended, the court stated that under the law the orders of the commission are final and not subject to court review unless they are beyond its statutory power or based on a mistaken interpretation of the law. This apparently gives the West Virginia commission almost unlimited power over rates and regulation of public-service corporations operating in that state. In the case in question it was contended that the company charged a regular rate of 25c. per thousand cubic feet for natural gas, reducing the rate to 22c. on five-year contracts. The commission ordered the practice abandoned and the decision was upheld by the court.

⁂

A Quarter Million Tons of Coal in Storage—A fuel agent and thirteen clerks are necessary to conduct the work of the fuel department of the Commonwealth Edison Co. and some of the allied Insull companies, according to C. E. McBride, who recently read a brief paper on the subject at a company section meeting of the N. E. L. A. The Commonwealth Edison Co. burns about 5000 tons of coal daily and its coal bill is about $2,000,000 a year. About 250,000 tons is kept in reserve in or near Chicago at all times. Nearly all of this is of egg or lump size, as the danger of fire from spontaneous combustion is much less with the larger sizes. Thermometers are placed in all coal piles and weekly records of temperatures are taken. It is frequently found necessary to move piles of screenings or mine-run coal to prevent or fight fires.

POWER

Vol. 39 NEW YORK, MARCH 10, 1911 No. 10

Self-Interviews

"But you know it's your own fault, Bill," said Bill Isolated-Plant Engineer. "That central-station fellow sized you up in no time that day he called 'just to look things over.' He saw you kept no records, that you were not as careful as you should be about buying coal. But when he saw that you were blowing hot condensate and steam to the sewer, and later, in the manager's office, compared the coal bills with what he judged to be the plant's average output, he knew you were easy."

"Now he's agreed to operate the plant on his company's current for less than you're furnishing it, and it's dollars to doughnuts the manager will sign."

"'Tain't fair," replied Bill Isolated-Plant Engineer, "if the manager was any good he'd hold off until I made a few test runs and gathered some data. But no, he's fallin' for this silver-tongued chap without giving me a chance."

"Wrong again, Bill," admonished William. "You've had a chance that was six years long. Things were going so easy like, you got to believe the job would last forever. You kept no records or check on the plant's performance. Book and cost keepin' wasn't your job."

"Now this fellow comes, looks around a while and tells the boss he's losin' money and losin' it fast, and shows pages of data to prove it."

"But I tell you we're not losin' money! The plant never ran better," pleaded Bill.

"I don't doubt it. But the fellow backs his statements with comparative figures. You deny him but offer nothing stronger than denials and angry protests. What do you expect the boss to do when you can't produce the figures he calls for?"

"Bill, you've been caught napping and you awoke too late to save this job. Remember, that fellow will visit your next plant; get to the boss with records and data before he does and show him that you can beat him at his own game."

[*Suggested by "Intimate Interviews" in "Life."*]

Remodeled Railway, Electric and Ice-Making Plant at Hampton, Va.

By Warren O. Rogers

SYNOPSIS—Reconstructing an antiquated central station into a modern installation, housed in the old building. Turbine generators have displaced reciprocating units, new pipe lines have been put in and a new coal-conveying system is operated by one man, whereas six were formerly employed. The inefficient ice-making plant has been brought up to full capacity.

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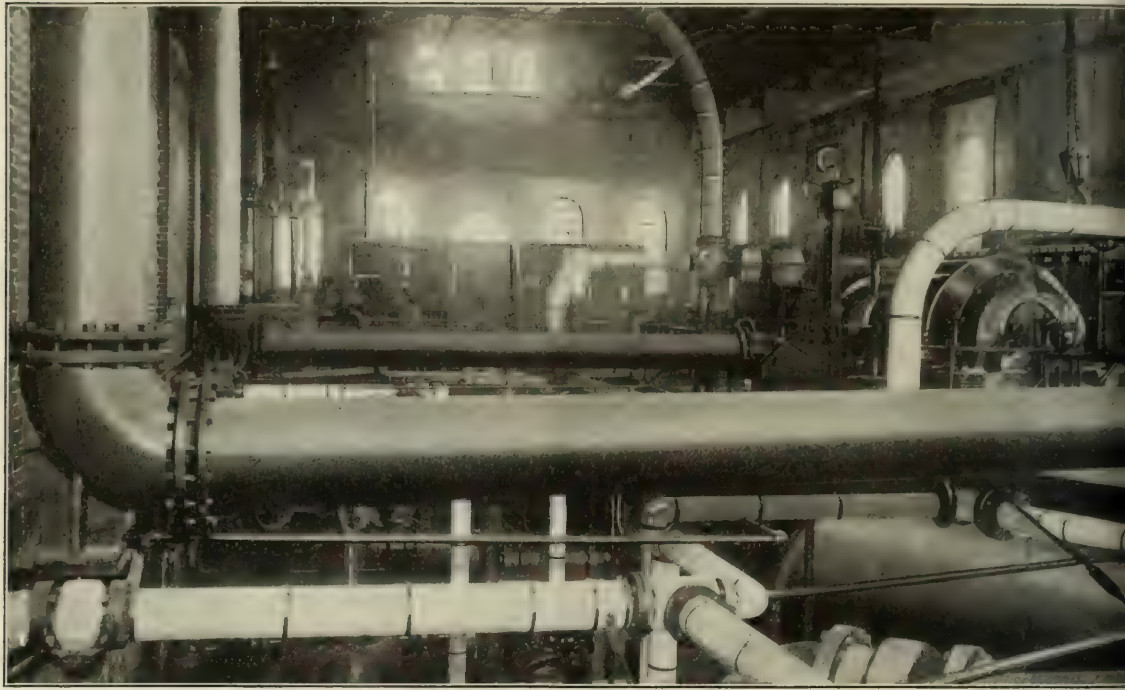


FIG. 1. GENERAL VIEW OF THE TURBINE ROOM OF THE NE

When a central steam-power plant has become obsolete and is still kept in use, it indicates that the management is not alive to modern economical plant operation, and is endeavoring to supply customers with electrical energy from machinery that is inefficient and often inadequate to give satisfactory service.

An example of remodeling an old steam plant is that of the Newport News & Hampton Railway, Gas & Electric Co., Hampton, Va. This was done without interrupting the service, and is a work of credit to the engineers, Allen & Peck, Syracuse, N. Y.

The original equipment, installed in 1900, consisted of one 150-kw., 10,000-volt, three-phase, vertical turbine; one 750-kw., 3450-volt, engine-driven generator, a 500-kw., 500-volt., direct-current, engine-driven set, two 325-kw., 500-volt, engine-driven units and one 800-kw., 3450-volt engine-driven generator. There was also a miscellaneous collection of exciters, transformers, condensers and other power-plant apparatus.

PRESENT PLANT

As the plant now stands, the equipment is most modern. The turbine room is made with a basement and balcony across both ends and along one side, from end to end. A general view is shown in Fig. 1. At the far end of the room, level with the balcony floor, is the 1800-kw. vertical turbine, the only unit taken over from the old plant. This generator was originally wound for 1500 kw. capacity, at 10,000 volts, but was rewound for 3450 volts, to work in parallel with the two 2000-kw., horizontal units. These three units generate three-phase, 60-cycle, 3450-volt current. The horizontal units (Fig. 1) are at the side and at the opposite end of the room from the vertical turbine.

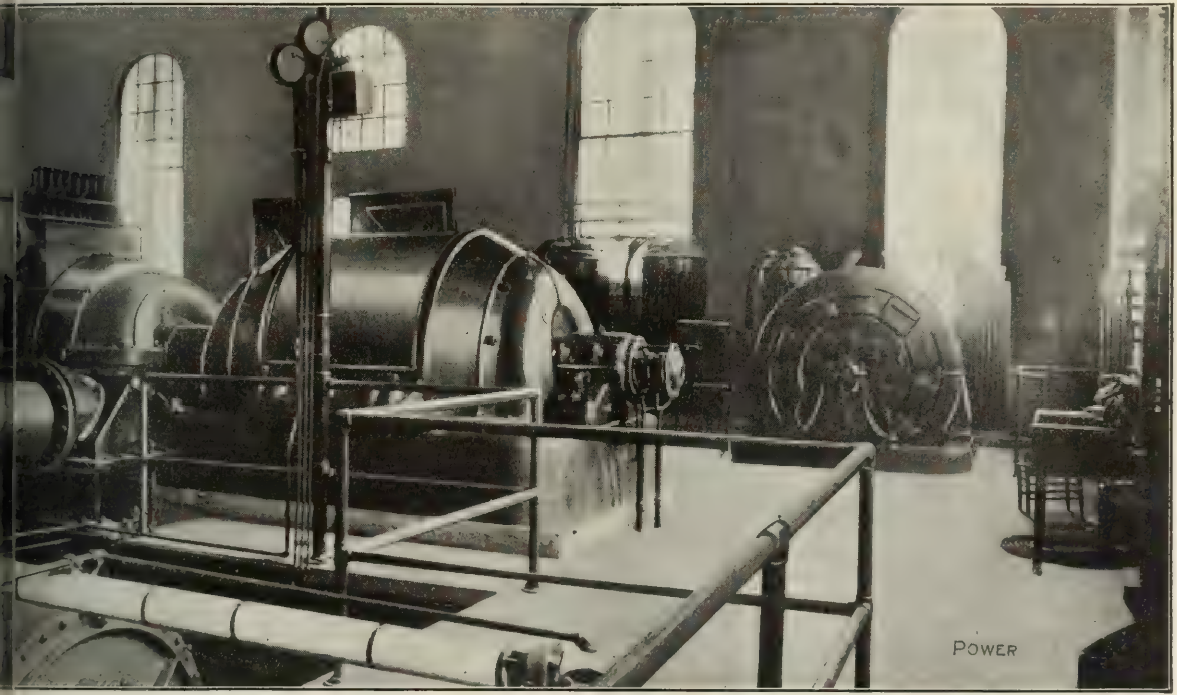
All condensing equipment is in the basement. That for the vertical turbine consists of a surface condenser and a turbine-driven circulating pump, a reduction gear being used between the circulating pump and the turbine. There is also an 8 and 18 by 12-in. air pump working at 105 r.p.m. These units are shown in Fig. 2. The step bearing is supplied with water by a 9 and 2 by 12-in., outside-packed, duplex pump at 400 lb. pressure. There are also two 6 and 2½ by 6-in. pot-valve pumps for emergency use.

At the opposite end of the turbine room are two 2000-kw. turbine units, generating 3450-volt, three-phase, 60-

cycle current, at 3600 r.p.m. Each unit exhausts into a separate surface condenser, of 6000 sq.ft. of cooling surface, or 3 sq.ft. of cooling surface per turbine kilowatt.

Air for cooling the turbine generators is supplied and discharged through two parallel air ducts, 9 ft. high and 4 ft. wide, running lengthwise of the basement. These ducts separate the electrical equipment in the basement from the steam auxiliaries. The air supply is controlled by a damper for each machine.

The condensers for the horizontal turbine are shown in Fig. 3, resting on concrete blocks at each end. This setting gives easy access to the condenser heads and to the piping. The two 15-in. circulating pumps are each driven by a 45-hp., side-crank engine. There are also two 8 and 18 by 12-in. air pumps, each piped to one condenser. These units are between the condensers and the side wall of the basement. A view of the 2000-kw. turbines and the opening above the condenser basement is shown in Figs. 1 and 4.



vs & Hampton Railway Power Plant

Operating Troubles

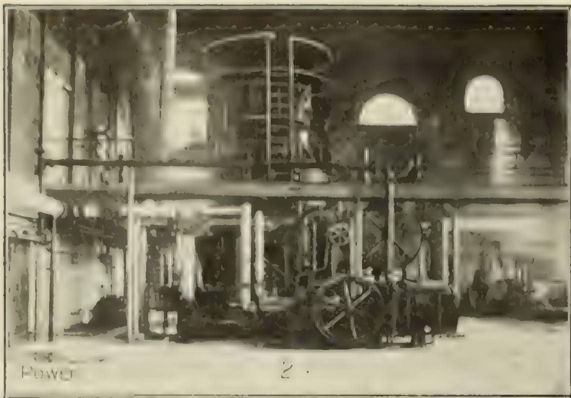
With the old equipment, interruptions of service were frequent, due largely to loss of circulating water during low-tide periods. The condensing salt water was taken from a creek at a point at the rear of the power plant. This trouble was found to be due to the poorly constructed wooden intakes and to the two suction lines, 200 and 300 ft. long respectively. The intakes were of insufficient depth and were fitted with fixed screens which made cleaning difficult. This trouble has been eliminated by the construction of a concrete intake with the bottom 5 ft. below extreme low tide. It is equipped with double removable screens, having an area of four times that of the intake tunnel. The intake tunnel is 4 ft. wide and 8 ft. deep, and so constructed that the water flows to a point below the circulating pumps by gravity; at extreme low tide the tunnel contains 4 ft. of water at these points. The discharge tunnel, of the same size as the intake, is pitched so that the water discharges to the creek by gravity.

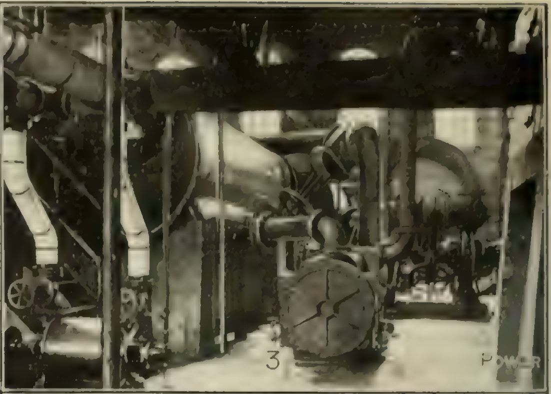
With the old condenser, containing $\frac{5}{8}$-in. tubes, trouble was experienced with floating débris, fish and sea growths. In the new equipment 1-in. condenser tubes are used. Provision has also been made for flushing the condenser tubes by reversing the flow of circulating water.

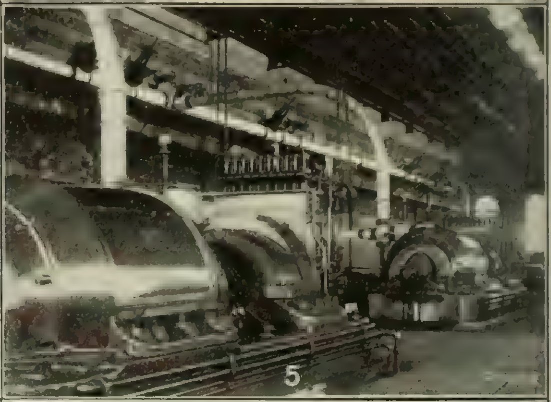
At times a combination of low tide and westerly wind tends to empty the creek. To provide against this, a 42-in. valve is placed between each condenser and turbine to permit of operating noncondensing. The atmospheric exhaust pipes are run across the condenser pit, as shown in Fig. 1, and pass through the roof.

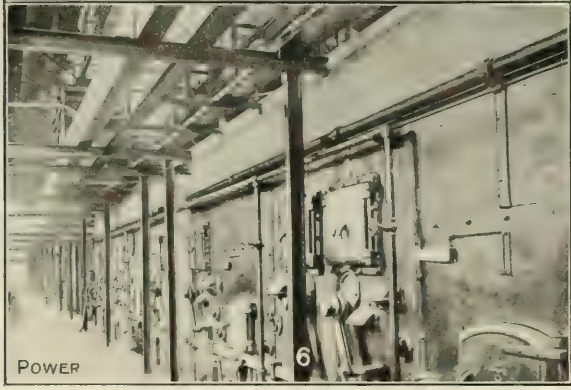
Antiquated pipe construction encumbered the old boiler room, and most of the steam lines were run in duplicate from a double steam header back of the boilers, all in positions difficult to get at. The steam loss in the pipe lines and old equipment was so great that just previous to installing the new pipe lines an additional 500-hp. boiler was required.

The new steam header is erected in the turbine room, Fig. 5. Below it is a steel gallery which brings every valve and fitting in the header within reach for repairs, etc. The header, of 12-in. pipe in the center, reduces to 8 in. at the far end of the room and to 6 in. at the opposite end. It is made up of cast-steel fittings and van-stone joints, in anticipation of the use of superheated









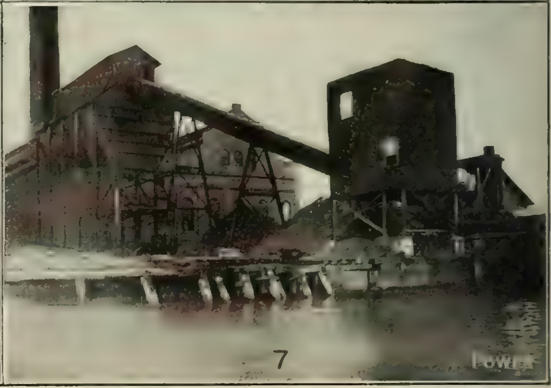


FIG. 2. THE 18,000-KW. VERTICAL TURBINE AND CONDENSING APPARATUS. FIG 3. SURFACE CONDENSER EQUIPMENT IN THE BASEMENT. FIG. 4. LOOKING TOWARD THE 2000-KW. TURBINE. FIG. 5. STEAM HEADER AND BRANCH PIPING. FIG. 6. BOILER ROOM AND MOTOR-OPERATED COAL BARNEY. FIG. 7. LOCOMOTIVE CRANE, COAL-CRUSHING HOUSE AND 500-TON OUTSIDE STORAGE BIN

steam, and is supported at six points by brackets attached to the wall. The header is supplied with steam through 6-in. pipes from the boiler. A steam line for the auxiliary units in the basement connects to the bottom of the header and drops to the basement.

In the old plant the boiler-feed pumps were in the basement of the boiler room. They have been replaced by two turbine-driven centrifugal pumps placed in the turbine room. They run at constant speed and the supply of feed water for the boilers is regulated by a valve in each brass boiler-feed pipe. It has been found that with all feed valves closed the increase in pressure in the feed line is but 5 per cent.

Fresh water, from the city main, is used for cooling step bearings, etc. To economize, all clean, fresh water is elevated from a sump by either of two motor-driven centrifugal pumps to a tank above an open heater and is automatically fed to the heater as makeup water. In case of insufficient makeup water, city water is automatically fed to the tank.

Air for blowing out armatures, operating boiler-tube cleaners and handling ice, etc., is supplied by one of two vertical 11 and 11 by 12-in. air pumps which are secured to a frame made of I-beams and fastened to the wall. This allows for cleaning about the pumps and for free access for repairs.

AUXILIARY APPARATUS

On the turbine floor, between the 2000-kw. units and the side wall, are two rotary converters for 600-volt street-railway work. About midway of the turbine room are three exciter sets, each of 125 volts. One 50-kw. set is driven by a 75-hp. induction motor at 1165 r.p.m. The other two 125-volt generators are driven by 25- and 35-kw. turbines at 3600 r.p.m. each. The exhaust steam from the turbines is used for heating boiler-feed water.

At the end of the 11-panel slate switchboard are three 750-kv.-a., 60-cycle, three-phase, transformers which step up the current from 3450 to 10,000 volts at which it is transmitted to Newport News, and then transformed for local use. There is also a 15-kw., constant-current transformer for arc-light circuits. Six 165-kv.-a. oil-cooled transformers are used for motor circuits.

BOILER ROOM

The nine water-tube boilers consist of one 500-, two 400- and six 250-hp. capacity, Fig. 6, under 150 lb. pressure. Before the alterations the boilers were supported by steel I-beams which rested on I-beam girders, exposed to the corrosive action of moisture and gases from the ashes. Brick and concrete-floor arches were built in between the floor beams which had deteriorated so badly that the weight of the boilers had caused some of them to sag 1 in. in the center. These beams were reinforced by placing new ones under the old and all were then encased in concrete.

As a matter of economy and to assist in case of failure of the city water, the boiler-blowoff water is blown into a concrete tank 40 ft. long, 11 ft. wide and 4 ft. deep, divided at the center by a charcoal filter. One end of the tank receives the blowoff water and is fitted with a baffled vent to the atmosphere. The water passes through the filter to the other end of the tank, flows by gravity to the station sump and is then pumped to the feed-water heater and back to the boilers. Fig. 8 is a plan and Fig. 9 an elevation of the turbine room. The dotted lines indicate future equipment.

COAL- AND ASH-HANDLING EQUIPMENT

Coal is delivered in 500-ton barge loads at the docks, Fig. 7. The new coal-handling equipment has a capacity of 50 tons per hour, and is operated by one man. The old equipment had a capacity of 10 tons per hour and required six men to operate it. There was no outside storage capacity. With the new equipment, the coal is delivered to the crushing rolls and scale by a steam locomotive crane and is then conveyed to the outside 500-ton steel-suspended bunker by a belt conveyor. From the outside bunker the coal is delivered to the boiler stokers by a motor-operated two-ton barney which runs on a track above the stokers, as shown in Fig. 6. The outside storage of 2000 tons is necessary as the design of the boiler house does not permit of sufficient space for an overhead bunker.

Ashes are loaded from the stoker ash hoppers into a standard-gage flat car in the basement, and are hauled away by a trolley locomotive. This eliminates handling the ashes before unloading the car.

ICE PLANT

In connection with and adjacent to the power plant is a 100-ton ice plant, containing one 40-ton and one 60-

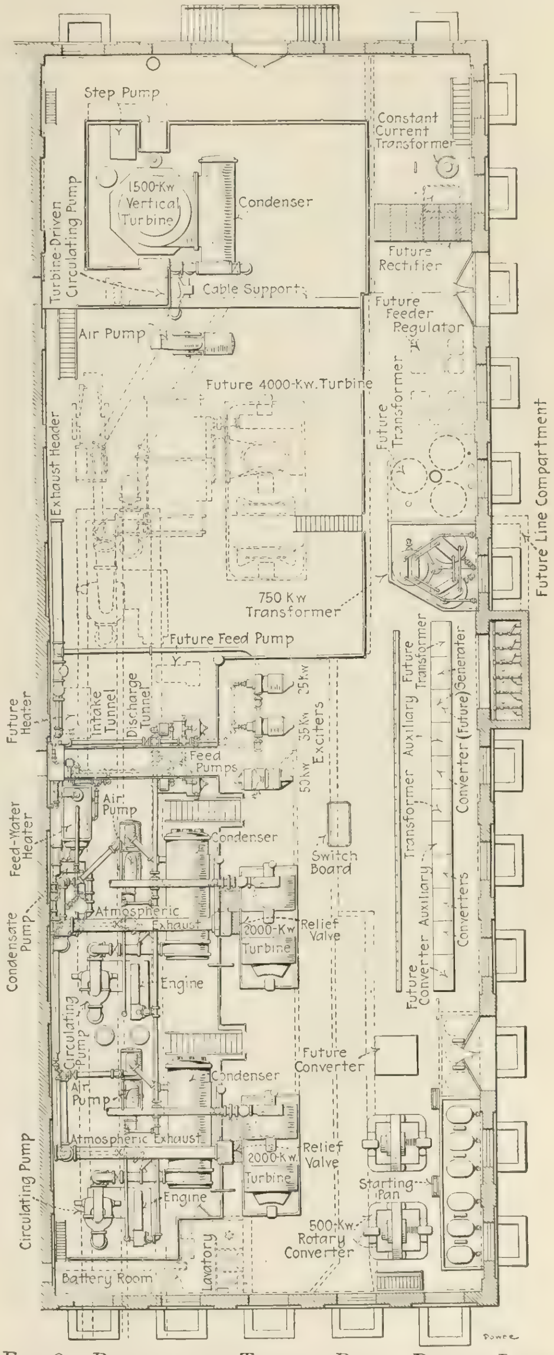


FIG. 8. PLAN OF THE TURBINE ROOM. DOTTED LINES SHOW FUTURE INSTALLATIONS

ton capacity ammonia compressor. The small unit has 14x28-in. and the other 16x24-in. tandem-compound condensing cylinders, Fig. 10.

The ice plant was as badly worn out as the power plant. The freezing tank of the 40-ton machine had been discarded, and because of inadequate auxiliary facilities both compressors were operated on the 60-ton tank during hot weather and then failed to obtain its full capacity. Since the plant has been overhauled an average output of 105 tons of ice per day can be maintained, and in addition a storeroom is refrigerated.

Atmospheric ammonia condensers are used. The stands are 20 ft. long, made up of 2-in. pipes, 12 pipes high. There are five stands for the 40-in. machine and seven for the 60-ton unit. Approximately 60 gal. of water per min. are required for each stand.

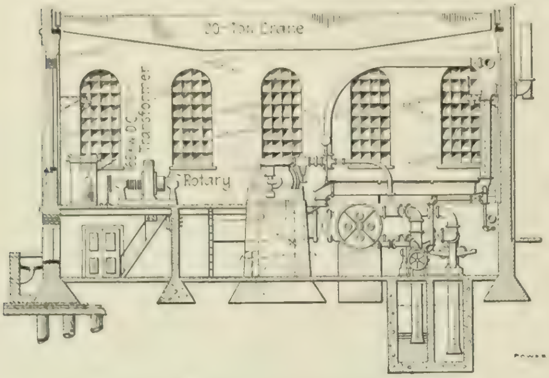


Fig. 9. Elevation of Turbine Room

The coolers are made of galvanized-iron, standard-weight pipe, and 30 gal. of water are used per min. per stand.

The freezing tank for the 40-ton unit contains 12,880 ft. of 1¼-in. pipe and 596 cans, each of 300-lb. capacity. This tank is operated as a wet-gas system, a 30-in. by 8-ft. accumulator being set in the tank.

The 60-ton tank contains 12,036 ft. of 1¼-in. pipe and 720 ice cans, each of 300-lb. capacity. This has been changed to a wet system by the addition of two 20-in by 8-ft. accumulators.

The new handling rooms for the small and large compressors are of 450 and 750 sq.ft. respectively. They with two storage rooms of 680 tons capacity, are refrigerated by direct expansion. The storage tanks are cooled by direct expansion instead of passing the return gas from the freezing tank through the coils.

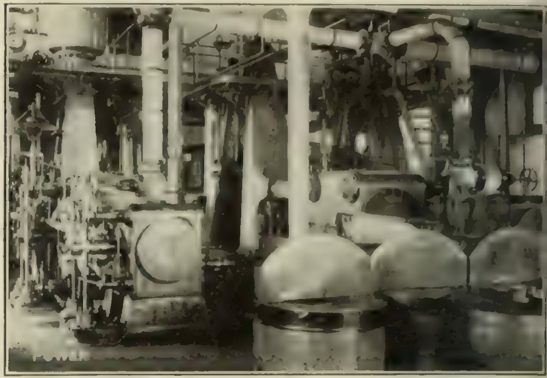


Fig. 10. Partial View of the 40- and 60-Ton Ammonia Compressors

PRINCIPAL EQUIPMENT OF NEWPORT NEWS AND OLD POINT COMFORT RAILWAY AND ELECTRIC CO.'S POWER PLANT

No	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbine	Curtis, vertical	1800 kw	Main generator	900 r.p.m. 150 lb., sat. steam, condensing	General Electric Co.
2	Turbines	Curtis, horizontal	2000 kw	Main generators	3600 r.p.m., 150 lb., sat. steam, condensing	General Electric Co.
1	Turbine	Terry		Circulating pump	150 lb. steam, 2500 r.p.m., non-condensing	Terry Steam Turbine Co.
2	Turbines	Alberger		Boiler feed pumps	Non-condensing, 150 lb. steam	Alberger Pump & Condenser Co
1	Turbine	Curtis	35 kw	Driving exciter	3600 r.p.m., 150 lb. steam, non-condensing	General Electric Co.
1	Turbine	Curtis	25 kw	Driving exciter	3600 r.p.m., 150 lb. steam, non-condensing	General Electric Co.
2	Engines	Horizontal side crank	8x10″	Circulating pumps	Variable speed	Ridgeway Dynamo & Engine Co
2	Generators	Alt. current	2000 kw	Main generators	3600 r.p.m., three-phase, 60-cycle, 3450 volt	General Electric Co.
1	Generator	Alt. current	1800 kw	Main generator	900 r.p.m., three-phase, 60-cycle, 3450 volt	General Electric Co.
1	Generator	Direct current	50 kw	Exciter	1165 r.p.m., 125 volt	General Electric Co.
1	Generator	Direct current	35 kw	Exciter	3600 r.p.m., 125 volt	General Electric Co.
1	Generator	Direct current	25 kw	Exciter	3600 r.p.m., 125 volt	General Electric Co.
2	Motors	Induction	3 hp	Make-up pump	1800 r.p.m., 220 volt, three-phase, 60 cycles.	General Electric Co.
1	Motor	Induction	75 hp	Driving exciter gen	1165 r.p.m., three-phase, 60 cycle	General Electric Co.
1	Pump	Centrifugal	14″	1800 kw. unit circ. water		Platt Iron Works Co.
1	Pump	Reciprocating	8x18x12″	1800 kw. unit condenser, air	150 lb. steam, 105 r.p.m	C. H. Wheeler Mfg. Co.
1	Pump	Outside racked	9x2x12″	Step bearing	400 lb. pressure	Henry R. Worthington
2	Pumps	Pot valve, duplex	6x2⅛x6″	Step bearing	400 lb. pressure	Henry R. Worthington
2	Pumps	Centrifugal	15″	Circ. water	Engine driven	C. H. Wheeler Mfg. Co.
2	Pumps	Mullen, air	8x18x12″	Surface condensers	150 lb. steam, 29″ vac	C. H. Wheeler Mfg. Co.
2	Pumps	Five stage	2½″	Boiler feed	Continuous	Alberger Pump & Condneser Co.
2	Pumps	Centrifugal		Make-up water	Motor driven, 1800 r.p.m.	C. H. Wheeler Mfg. Co.
1	Condenser	Surface	6M. sq.ft. cooling surface	1800 kw. vertical unit	29″ vacuum	C. H. Wheeler Mfg. Co.
2	Condensers	Surface	6M. sq.ft. cooling surface	2000 kw. units	29″ vacuum	C. H. Wheeler Mfg. Co.
1	Reducing gear	Folk		Between turbine and cir. pump		Foote Bros. Gear & Mch. Co.
1	Heater	Open Cochrane		Feed water	Exhaust steam	Harrison Safety Boiler Works
1	Transformer	Constant current	15 kw	Arc lighting	Primary 3120 volt, 6.6 amp	General Electric Co.
3	Transformers	Three phase	750 kv.a	Power and lighting	3450 to 10,000 volts, 60 cycle	General Electric Co.
6	Transformers	Oil cooled	165 kv.a	Motor circuits	3450 to 430 volts	General Electric Co.
1	Boiler	Water tube	500 hp	Steam generators	150 lb. pressure, hand fired	Heine Safety Boiler Co.
2	Boilers	Water tube	400 hp	Steam generators	150 lb. pressure, mechanical stokers	Babcock & Wilcox Co.
6	Boilers	Water tube	250 hp	Steam generators	150 lb. pressure, mechanical stokers	Babcock & Wilcox Co.
8	Stokers	Murphy		Boiler furnace	Mechanical	Murphy Iron Works
1	Conveyor	Belt		Conveying coal	Intermittent, motor driven	Exeter Machine Co.
1	Crane	Locomotive	10 ton	Conveying coal	Intermittent, steam driven	Brown Hoisting Machinery Co.
1	Compressor	Ammonia	40 ton	Ice plant	Steam driven, tandem comp., cond	Frick Co.
1	Compressor	Ammonia	60 ton	Ice plant	Steam driven, tandem comp., cond	York Mfg. Co.

Legal Aspects of Boiler Explosions

By A. L. H. Street

SYNOPSIS—Liability for injury to person or property is tested by failure to use that degree of care exercised by an ordinarily prudent person. Responsibility of insurers, manufacturers and employees. Appellate court decisions on the subject reviewed.

Legal liability in damages for injury to person or property, resulting from explosion of a boiler, must, according to repeated decisions of the courts, rest upon failure to use that degree of care to avoid an explosion that a person of ordinary prudence would use in the same or similar circumstances.

For the purpose of applying this principle, the negligence of an employee must be attributed to his employer, rendering the latter responsible for any injury resulting to a third person (West Virginia Supreme Court of Appeals, 41 Southeastern Reporter 187).

But a presumption of negligence does not arise from the mere explosion of a boiler used in a lawful business; negligence attributable to the person in control of it must be affirmatively shown. Announcing this principle in the case just cited, the West Virginia court pointed out that the American courts follow a different rule from that applied by the English bench. In England an owner of land is *prima facie* liable for injury caused by any dangerous instrumentality which he may have constructed thereon. "But such is not the American law. That law says that the English rule detracts from the efficiency of that ownership, cripples a plain right of ownership, and makes that owner an insurer against harm to others resulting from mere accident in the lawful use of his property."

This same rule has been applied by the Colorado courts, in holding that the fact that a boiler exploded, injuring an adjoining building, created no presumption of negligence on the owner's part, in the absence of a showing that the boiler was defectively constructed or improperly maintained (61 Pacific Reporter 50). But the Michigan Supreme Court has held that proof that a boiler exploded when subjected to a steam pressure of 80 lb., with the safety valve set to blow off at 90 lb., established *prima facie* negligence on the part of the owner, where it appeared that the boiler was safe only under a pressure of 60 lb. or less (87 Northwestern Reporter 793).

In a Rhode Island case, it was decided by the supreme court that one who sued for personal injury, caused by a boiler explosion, made out a *prima facie* case of negligence in subjecting the boiler to an extraordinary pressure, by showing that it burst when apparently in good condition and capable of withstanding ordinary pressure (69 Atlantic Reporter 69). But if the cause of an explosion cannot be definitely ascertained and if the circumstances shown to have existed are just as consistent with a cause for which the owner of the boiler is not responsible as with a cause for which he would be responsible, there can be no recovery; damages will not be awarded upon a conjecture as to the real cause of the accident (Kentucky Court of Appeals, 48 Southwestern Reporter 434). In a Michigan case, wherein the plaintiff claimed that bursting of a boiler resulted from defendant's failure to properly inspect it, the supreme court held that it was open to defendant to show that it was not practicable to remove the flues to ascertain the condition of the braces which the plaintiff claimed were defective (91 Northwestern Reporter 647). But it is to be noted that, ordinarily, an owner of a boiler is just as much responsible for failure to discover a defective condition existing in it, as he is for omitting to repair a defect known to him (Michigan Supreme Court, 99 Northwestern Reporter 27).

Evidence of precautions taken by the owner, *after* an explosion, to avoid recurrence of a similar accident, cannot be shown in evidence as an implied admission of negligence in the manner in which the exploding boiler was maintained (Pennsylvania Supreme Court, 51 Atlantic Reporter 979). But in a suit for injury to a building caused by explosion of a boiler in an adjoining building, it was held by the Pennsylvania supreme court that it was no defense that the boiler had been inspected by a boiler-insurance company, in the absence of further proof that the inspectors were competent, and that they properly inspected the boiler and made a true report (56 Atlantic Reporter 345). The court decided that, in order to relieve defendant from liability, there must have been no evidence of want of care in selecting mechanics to make proper repairs, and that an inspection must be shown to have been made by competent persons after the repairs were made and before the explosion occurred.

The employee of a boiler owner, to whose negligence an accident is directly attributable, as well as the owner, may be held responsible to a third person who has been injured in person or property by the explosion complained of. The personal responsibility of an engineer for injury to another, resulting from an explosion due to an insufficient water supply, depends upon the inquiry whether he used that degree of care to keep the water at the proper point in the boiler which an ordinarily careful engineer would use in like circumstances (Connecticut Supreme Court of Errors, 85 Atlantic Reporter 380).

A boiler-insurance company may be held liable for injury to a third person caused by bursting of an insured boiler, if the company coöperated actively with the owner of the boiler in its management, so far as the injury is attributable to the company's failure to use a proper degree of care and skill (19 Atlantic Reporter 472). The decision in this case is authority for stating that all persons, whether owner, employee or volunteer, are responsible for injury resulting from mismanagement of a boiler. But, in another case, a United States circuit court held that another boiler-insurance company, not being an insurer as regards a third person, was not responsible for his death, resulting from explosion of an insured boiler, even though the company certified that the boiler had a higher degree of strength than was the fact, unless the so doing was the result of negligence (19 Federal Reporter 246).

And, although a buyer of a boiler is entitled to recover from the manufacturer damages caused by an explosion resulting from defective construction (156 Pennsylvania Supreme Court Reports 156), the manufacturer is liable to the buyer only for any defects, and not to a third person who may be injured on account thereof (51 New York Reports 494).

As to injuries to employees, it is generally held by the courts that their employers must use reasonable care to see that their places of work are reasonably safe. It is to be noted that the duty is not an absolute obligation to keep the places absolutely, or even reasonably, safe. Therefore, the liability of an employer for injury to an employee resulting from bursting of a boiler is tested by the question whether the employer has used a reasonable degree of care to see that the boiler was reasonably safe. Cases involving injury to workmen, however, are often taken outside the principles applicable to outsiders, as above outlined, by reason of the arising of questions of assumption of risk, contributory negligence, and negligence of co-employees. Thus, notwithstanding the fact that an employer may have permitted a boiler to remain in an unsafe condition, there is no liability, under the general rules of law as applied by the courts, if the employee voluntarily encountered the risk of an explosion when an ordinarily prudent employee would not have done so, or if he failed to perform any duty resting upon him to make an inspection for his own safety, or if the explosion resulted from negligence of a co-employee in a state where the "fellow servant doctrine" is in force.

* *

Cost of Operating a Gas-Producer Plant

By F. J. Rode

The power plant of the A. O. Smith Co., Milwaukee, has two 400-kw. Allis-Chalmers gas-engine units, one installed in 1910, and the other in 1911. The first was served by two 400-hp. Wood producers and the second unit by two Smith producers of 350 hp. each. The entire plant up to this time had been operated on hard coal of both buckwheat and pea sizes. In 1912, however, when hard-coal prices rose from $4 to $6 per ton in this vicinity, it was decided to operate the entire plant on soft coal.

First, Illinois coal was considered, as this could be delivered for $2.90 per ton at the plant; but after experimental operation on different kinds of coal, including West Virginia splint, Indiana, Illinois and Hocking Valley coals, Hocking Valley nut coal was found to deliver the largest number of kilowatt-hours for one dollar. The heat value per cubic foot of this gas averaged 160 B.t.u., and Sunday Creek Hocking showed as low as 1.5 lb. per kw.-hr., although the average for 1913 was near 2 lb.

Month	Hours of Running	Tons of Coal Consumed	Cost of Coal Consumed	Cost of Attendance	Cost of Supplies	Kw.-Hr. Output	Cost of Operation per Kw.-Hr., c.	Fixed Charges per Kw.-Hr.	Total Cost per Kw.-Hr.	Cost of Operation	Cost of Operating, Including Fixed Charges	Load Factor During Time of Operation
Jan	568	267.7	$930 00	$767.75	$109.75	325,400	0.556	0.279	0.835	$1807 50	$2707.50	0.715
Feb.	500	241	903.75	810.40	96.22	284,230	0.636	0.321	0.957	1810.37	2710.37	0.71
Mar	554	272	980.00	601.60	87.40	296,620	0.565	0.301	0.866	1669 00	2569.00	0.665
April.	304	168.4	586.00	407.65	63.80	190,700	0.558	0.464	1.020	1057.45	1957.45	0.78
May.	470	220	792.00	571.95	43.40	236,700	0.595	0.382	0.994	1407.35	2307.35	0.71
June.	244	140	504 00	437 45	48.64	142,000	0.697	0.683	1 33	990 09	1890.09	0.73
July.	235	185	660.00	405.45	43.10	134,000	0.825	0.660	1.485	1108.55	2008.55	0.715
Aug.	205	110	396 00	396.25	26.10	98,200	0.836	0.916	1.752	818.35	1718.35	0.60
Sept.	230	125	450.00	405.45	34.00	133,000	0.670	0.677	1.347	889.45	1789.45	0.712
Oct.	240	173.5	606.00	422.50	35.20	152,810	0.700	0.590	1.30	1063.70	1963.70	0.79
Nov.	215	163.5	590.00	396.55	32.30	144,990	0.705	0.620	1.325	1018.85	1918.85	0.837
Dec.	235	178	624.00	383.65	24.60	159,120	0.880	0.520	1.270	1032.25	1932.25	0.815
Total.	4000	2244.1	$8021.75	$6006.65	$644.51	2,297,770				$14672.91	$25472.91	
Aver. per mo.	333.33	187	668.48	500.54	53.71	191,480	0.634	0.470	1.104	1222 74	2122.74	0.73

Cost of operating, 1913		$14,672.00
Cost of deprecation taxes, interest and insurance		10,800.00
		$25,472.00
Cost of operating per kw.-hr.	0.634c.	
Cost of fixed charges per kw.-hr.	0.470c.	
Total cost per kw.-hr.	1.104c.	

A saving in the cost of operation of 0.3c. per kw.-hr. was effected by changing to soft coal. The price of coal varied during 1913, but at present the coal is delivered to the producers at $3.50 per ton. The change from hard coal to soft coal required a few changes in the Smith producer equipment, Smith static tar extractors being installed. This was the second equipment of its kind up to that time, and it has been found reliable and effective.

The Wood producers were equipped with rotary tar extractors when first installed; hence no changes were required. The tar is burned under steam boilers, which are used for drop-forge and heating purposes. No credit is allowed the gas plant, for this tar, although 9½ lb. of water are evaporated per pound of tar.

The accumulation of tar varies somewhat with the volatile matter in the coal. The Hocking Valley coal now used runs from 80 to 100 lb. per ton in the Smith producers, and somewhat higher in the Wood producers. Waste water is used for scrubbing and no charge is made in the report for water.

The waste heat of the gas-engine exhaust is utilized, the boiler plant being supplied with jacket water pumped through gas-engine exhaust heaters; all excess water is sprayed and reused.

The plant represents an investment of $80,000, and the fixed charges are taken at 13.5 per cent., which amount to $10,800 per year, or $900 per month. The accompanying tabulation shows the operating and total costs for 1913, as well as the monthly load and load factor.

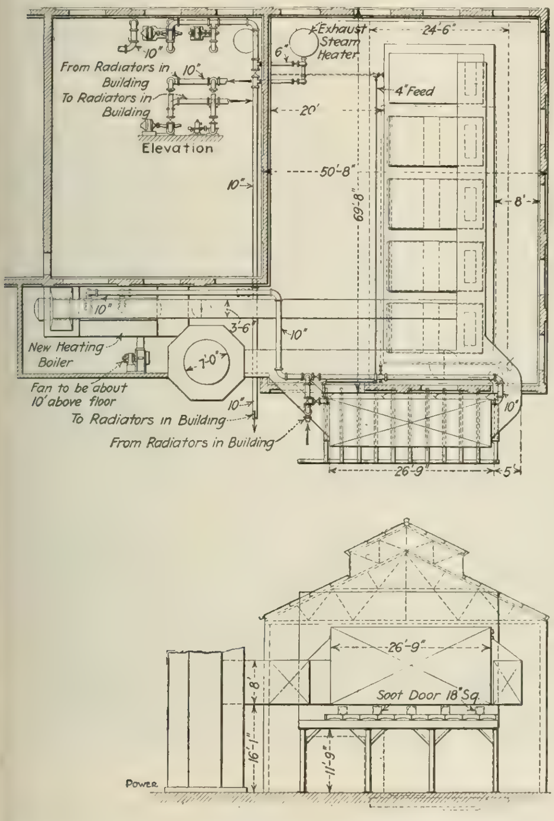
Repairs on the plant are included under "Cost of Supplies" and labor for such repairs in "Cost of Attendance."

Using an Economizer on a Hot-Water Heating System

By W. L. Durand

The use of an economizer for heating water for a forced hot-water system is sufficiently novel to warrant a brief description of a recent installation at the plant of the Farrel Foundry & Machine Co., Ansonia, Conn.

The original heating system was installed several years ago, and a live-steam heater and a 150-hp. water-tube heating boiler were used for heating the water. Because of rapidly increasing demand on the heating system, as new buildings were added, the boiler and heater were of insufficient capacity. Furthermore, the space where the boiler was located was required for a steam boiler to take care of the increased load on the engines.



Position of Economizer and Pipe and Smoke Flue Connection

The power plant consists of 1600 hp. in water-tube boilers and an engine-low-pressure turbine plant. It was found that greater yearly economy was obtained by using the exhaust from the engines in a low-pressure condensing turbine than for heating the water for the heating system.

After examining several different plans, the final selection was made on the basis of the minimum total annual expense, although the first cost was the highest. The system has now been in satisfactory operation for the greater part of the present heating season. The leading features are as follows:

The 150-hp. heating boiler was scrapped to make room for a new steam boiler, and heating apparatus was installed, partly in the form of an economizer and partly as a heating boiler, and sufficient altogether to provide for 65,000 sq.ft. of radiation, which allows for all possible future expansion on the present property.

The flue gases left the boilers at from 500 to 600 deg. F. An economizer was installed to utilize the available heat, which was estimated to furnish about one-third of the total required for the system under maximum weather conditions. On this basis, moreover, the same estimate indicates a capacity sufficient to provide for 50 to 60 per cent. of the total average heat required throughout the heating season. These estimates indicate the economy which the use of the economizer may be expected to secure.

The economizer consists of 44 sections, each section 10 tubes wide and each tube 12 ft. long, making a total of 7200 sq.ft. of heating surface. The branch pipes were increased from 4 to 10 in. to accommodate the large volume of water that is to be handled. One $2\frac{1}{2}$-in. safety valve was placed on each end of the economizer. It was found impossible to locate the economizer in the power house and it was, therefore, placed outside on structural-steel supports, as shown in the accompanying illustration. A house, of angle-iron frame and corrugated galvanized-iron covering, was built over the economizer to protect it from the weather. The roof is made in removable sections to permit of drawing tubes.

To provide the balance of the heating capacity, as required, a standard 285-hp. water-tube boiler, with longitudinal drum, was installed, so that in case it should ever be desired for power purposes, no changes would be necessary. The only special feature is a baffle-plate in the center, so arranged as to prevent the water from short-circuiting through the drum. This baffle-plate is made in sections and can be taken down and removed through the manhole if the boiler is to be used for power purposes. The water enters the rear of the drum and flows down the rear header, up through the tubes, up the front header and out at the front of the drum. Therefore, the flow of the water is in the same direction as the natural circulation in the boiler under steaming conditions.

Both economizer and boiler are provided with bypass connections, so that either one can be run without the other.

The dampers in the main smoke breeching and in the intake to the economizer are controlled by a thermostat located in the hot-water pipe leaving the economizer.

On account of the long run from the boiler to the main breeching, a balanced-draft system was installed to prevent the gases being blown out of the furnace door. The fan used is a centrifugal blower of the multi-vane type and is controlled by a thermostat located in the flow pipe leaving the boiler. By the use of the two thermostats any desired temperature is maintained in the circulating water.

The water is circulated by a double-suction, 1500-gal. per min. centrifugal pump, directly connected to a motor. The present pump is kept in reserve for use in case of emergency. An interesting point may be mentioned in connection with the circulation of the water. Two methods of pumping have been tried with the system. First, pumping the water through the boiler and economizer or heater and then to the heating system. Second, connecting the suction side of the pump to the boiler and economizer and pumping direct to the heating system. It was found after trial that much better results were obtained with the latter method, which is the one now in use.

An added economy is gained in the use of the economizer by connecting it to the boiler-feed line so that during the summer when the economizer is not used for the heating system it can be used to heat the feed water. The feed water now enters the boiler at about 200 deg.; if it passes through the economizer it is raised to between 280 and 290 deg. F.

In operating an installation of this kind, care should be taken to always keep the pump going. If the economizer is to be cut out or the pump stopped, the dampers to the economizer should be fully closed and if possible the economizer emptied of water. If this is done no danger from an explosion need be feared.

This installation was designed by and installed under the direction of Clark, MacMullen & Riley, consulting engineers, New York City.

⁂

Some Results of Twenty-Four-Hour Plant Test

By B. R. T. Collins

SYNOPSIS—This test was made on the entire power equipment of the Goodyear Tire & Rubber Co., of Akron, Ohio. Besides determining the performance of the different machines the most economical rate of driving the boilers was found and the cost of electricity generated by the low-pressure turbo-generators was computed.

⁂

About three years ago the management of the Goodyear Tire & Rubber Co., of Akron, Ohio, decided upon making a thorough and systematic operating investigation of all of its power equipment at least once every year to supplement its daily and monthly records of operating data and power costs and to bring out clearly the progress made in reducing the cost of power. The last of these investigations was made during July, 1913, one of the most important features of the work being a 24-hr. complete plant test. Before and after this test, a large number of special investigations were made to supplement the results of the longer test and enable definite comparisons of the relative efficiencies of similar kinds of equipment to be made.

Fig. 1. General View of Goodyear Plant

Among these tests were some on the Green L-type chain-grate stokers which are of special interest as they are the largest of this type yet placed in service. They are provided with inclined plates, located under the ignition arch and which break up any crust forming with a coking coal. There are six of these stokers installed under 822-hp. Stirling boilers.

The coal used was a mixture of Cambridge and Youghiogheny slack having 35.44 per cent. volatile combustible matter, 50.39 per cent. fixed carbon, 12.27 per cent. ash, 1.90 per cent. sulphur and a heat value of 13,572 B.t.u. per pound of dry coal.

The tests were made under ordinary working conditions, without special effort to obtain the highest efficiency, but to determine the capacity and efficiency with about one-half of the available natural chimney draft and with the full draft. The principal results were as follows:

TABLE I. DATA FROM DRAFT TESTS

	Half Draft	Full Draft
Duration of test, hr.	4	2
Horsepower developed	1418	1702
Percentage of rating developed	172.5	207.1
Dry coal burned per hr., lb.	4993	6351
Dry coal per hr. per sq.ft. of grate surface, lb	27.4	34.9
Equivalent evaporation per sq.ft. of heating surface per hr., lb.	5.94	7.14
Steam pressure, lb. per sq.in.	166.7	170.8
Temperature of feed water entering boiler, deg. F	213.8	214.0
Temperature escaping gases, deg. F	647.6	668.1
Draft in furnace, in. of water	0.25	0.45
Draft in uptake, in. of water	1.04	1.25
Draft in stack, in. of water	1.60	1.60
Percentage of moisture in steam at boiler	1.7	1.6
Water evaporated per lb. of coal, actual conditions, lb.	9.21	8.68
Water evaporated per lb. of dry coal from and at 212 deg. F., lb.	9.80	9.25
Efficiency of boiler and grate, per cent	69.5	69.0
Cost of coal to evaporate 1000 lb. of water from and at 212 deg. F.	$0.082	$0.087

As will be noted, the capacity with the full draft in the furnace of 0.45 in. of water as compared with 0.25 in. draft was 34.6 per cent. of the rating greater; the coal burned per square foot of grate surface per hour was greater by 7.5 lb., or 27.4 per cent.; the equivalent evaporation per square foot of heating surface per hour was greater by 1.2 lb., or 20.2 per cent.; the temperature of the flue gases was higher by 20.5 deg. F.; the equivalent evaporation was less by 0.55 lb., or 5.6 per cent.; the efficiency was less by 0.5 per cent. and the cost of coal to evaporate 1000 lb. of water was greater by $0.005, or 6.1 per cent.

The general conclusion reached was that it was not economical to run the stokers and boilers at the higher rating unless a shortage of boiler capacity required it; also in view of the high temperature of the flue gases, on both tests, it was decided to investigate the question of installing superheaters. Another reason for this investigation was the rapid wear on the blading of some of the small steam turbines, of which there are six in the plant.

Twenty-three men from the engineering, experimental and chemical departments of the company, working on two 12-hr. shifts, obtained the data required. This included records of the weights of coal burned under the boilers; weights of water pumped into the boilers as determined by the recording venturi meters; draft in furnaces, uptakes, and stack; flue-gas analyses in rotation from all of the boilers in service by means of an Orsat apparatus; calorimeter determinations of moisture in the steam at the boilers; temperature of flue gases and feed water at the heater and boilers; analyses of coal used and ash obtained; indicator cards from both the Fulton and Hamilton engines; steam pressure at throttles; receiver pressures; vacuums; temperatures of injection and discharge condensing water; temperatures of inside and outside air; barometer readings; pressure of hydraulic and compressed-air systems; electrical readings giving output of generators connected to Allis-Chalmers and Rateau turbines, as well as a record of the time of operation of all equipment in the factory using power. All readings were taken at 15-min. intervals during the entire 24 hr.

The principal data and results of the 24-hr. test on the boilers were as follows:

TABLE II. RESULTS OF 24-HR. TEST ON BOILERS

Number of boilers in service	5
Kind of Fuel—Cambridge and Youghiogheny Slack	
Percentage of ash and refuse	12.3
Fuel per hr. per sq.ft. of grate surface, lb.	25.1
Water evaporated per hr. per sq.ft. heating surface, lb.	5.00
Steam pressure, lb.	168
Temperature feed water entering boiler, deg. F.	213.7
Temperature of escaping gases, deg. F	626.1
Draft in furnaces, in. of water	0.285
Percentage of moisture in steam at boiler	1.1
Horsepower developed	6201
Horsepower in service, builders' rating	4110
Percentage of builders' rating developed	150.9
Water evaporated per lb. of fuel, actual conditions, lb.	8.65
CO_2 in flue gases, per cent	7.58
Oxygen in flue gases, per cent	12.40
CO in flue gases, per cent	0.014
Efficiency, per cent	68.4
Cost of fuel to evaporate 1000 lb. of water from and at 212 deg. F.	$0.0861

Heat Balance	Btu.	Per Cent.
Heat absorbed by the boiler	10,310	68.4
Loss due to moisture in fuel	59.7	0.40
Loss due to moisture formed by burning of hydrogen	757	5.02
Loss due to heat carried away in chimney gases	3,732.5	24.75
Loss due to incomplete combustion of carbon	15.0	0.11
Loss due to radiation, unburned fuel and gases, etc.	205.8	1.32
Total heat of 1 lb. of combustible	15,081.0	100.00

Coal Analysis	Per Cent
Moisture	3.92
Volatile combustible matter	34.13
Fixed carbon	51.30
Ash	12.57
Sulphur	2.63
Heating value, B.t.u. per lb. dry coal	13,410

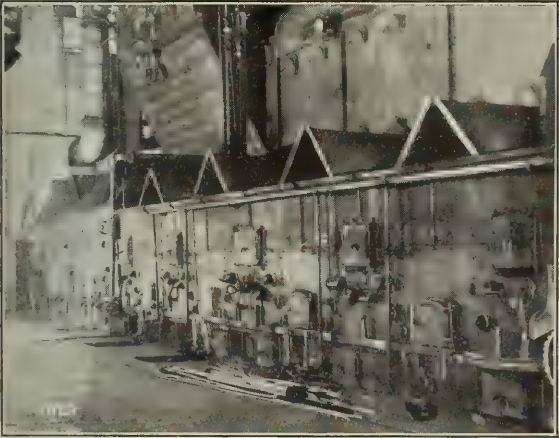


FIG. 2. STOKERS

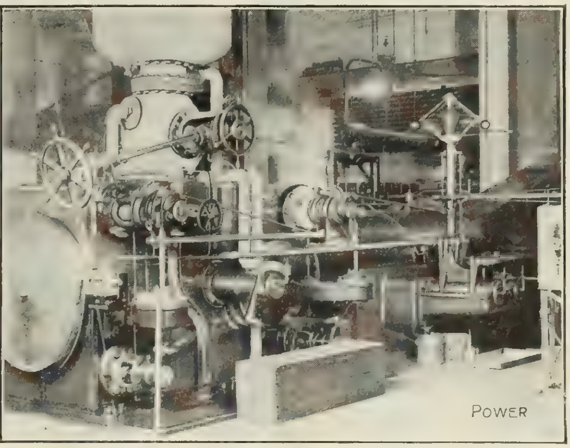


FIG. 3. 2500-HP. CORLISS ENGINE

It will be noted from these results that the average horsepower developed during the 24-hr. run was 6201, or 150.9 per cent. of the rating. This overload of about 50 per cent. has proved to be an economical point at which to run the boilers, as determined on tests made with boilers of similar capacity equipped with chain grates, installed by other companies.

The average efficiency obtained, 68.4 per cent., compares favorably with the efficiencies of 69.5 and 69 per cent. obtained on the shorter runs with a single boiler. The cost to evaporate 1000 lb. of water from and at 212 deg. F. was 8.6c. on the 24-hr. run as compared with 8.2c. and 8.7c. obtained on the short runs.

The 24-hr. average for CO_2 in the flue gases leaving the boilers was 7.58 per cent.; O, 12.4 per cent. and CO, 0.014 per cent., but the averages for the same time from three of the five boilers tested were CO_2, 10.30 per cent.; O, 9.03 per cent. and no CO. The reason for this difference was that on the two boilers having low values of CO_2 there was a space about 1 in. wide, extending the entire width of the furnace, between the stationary and movable portions of the arch over the grate. This opening allowed a large amount of air to enter the furnace directly over the coking plates, while on the three other boilers this opening was closed with asbestos, allowing no air to enter at this point, but not preventing the circulation of air for cooling the arch.

To show the effect on the heat balance of closing this opening, the results from these three boilers were figured to show the loss due to heat carried away in the chimney gases, which amounted to 18.7 per cent., as compared with 24.75 per cent. for the entire 24-hr. run. Assuming that five-sixths of this heat would have been transmitted to the boiler, the efficiency of the boiler would have been increased to 73.4 per cent.

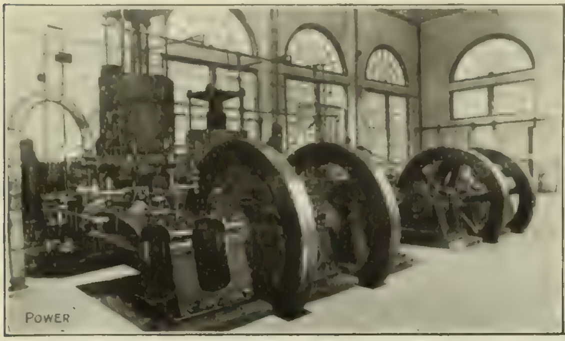


FIG. 4. TWO 200-GAL. HIGH-PRESSURE PUMPS

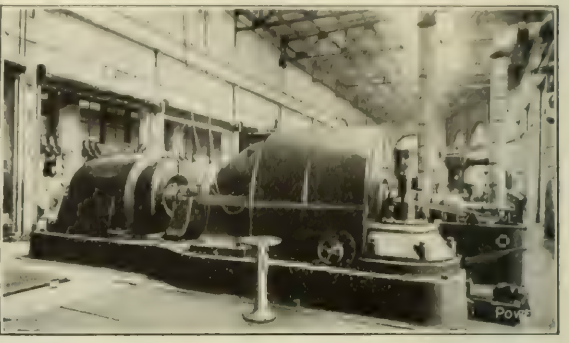


FIG. 5. MIXED-PRESSURE TURBINE

TABLE 3. GENERAL RESULTS OF 24-HR. PLANT TEST

Fulton engine, average i.hp.	1400
Hamilton engine, average i.hp.	1579
Pressure in exhaust header, lb. per sq.in	1.52
Rateau turbine, low-pressure inlet pressure, in. of mercury	7.83
Rateau turbine, high-pressure inlet pressure, lb. per sq.in	11.9
Vacuum, in. of mercury	27.04
Allis-Chalmers turbine, low-pressure steam pressure, in. of mercury	4.15
Allis-Chalmers turbine, low-pressure inlet pressure, in. of mercury	11.36
Vacuum, in. of mercury	27.01
Average total engine horsepower	2979
Engine load factor, per cent	74.5
Average total output, kilowatt	1690.8
Turbine load factor, per cent	53.2

Table 3 gives only a few of the results of the 24-hr. plant test. While much of the data obtained is of value only to the Goodyear company, there is one result which should be of general interest; this relates to the cost of electric power generated by the low-pressure turbo-generators. Practically all of the steam for operating these turbines came from the two cross-compound Corliss engines which developed an average of 2979 hp. during the test. If these engines had been operating condensing they would probably have developed about 20 per cent. more power, so that the cost of the steam for this 600 hp. is all that should be charged up to the turbines so far as steam consumption is concerned.

TABLE 4. PRINCIPAL EQUIPMENT UNDER 24-HR. TEST

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Boilers	Stirling	822-hp.		175-lb. steam pressure	Babcock & Wilcox Co.
5	Stokers	Chain grate	182 sq.ft.			Green Engineering Co.
1	Engine	Cross-compound	1500 hp.	Driving line shafting	Noncondensing	Fulton Iron Works
1	Engine	Cross-compound	2500 hp.	Driving line shafting	Noncondensing	Hooven, Owens, Rentschler Co.
1	Engine	Cross-compound	450 hp.	Driving air compressor	Noncondensing	C. & G. Cooper
1	Turbo-generator	Low-pressure	1500 kw.		Condensing	Southwark Foundry & Machine Co. Crocker-Wheeler Co.
1	Turbo-generator	Mixed-pressure	1680 kw.		Condensing	Allis-Chalmers Co.
1	Condenser			With Allis-Chalmers turbine		Allis-Chalmers Co.
1	Condenser	Le Blanc		With mixed-pressure turbine		Westinghouse Machine Co.
1	Steam turbine			With Allis-Chalmers condenser		Terry Steam Turbine Co.
1	Air compressor	Two-stage	16½ & 27¼x36-in.			Ingersoll-Rand Co.
2	Steam pumps	Direct-acting	14 & 20x3¾x24-in			Laidlaw-Dunn-Gordon Co.
1	Motor driven pump	Two-stage	5000-gal		Discharging against 100 lb.	De Laval Steam Turbine Co., Pump Crocker-Wheeler Co., Motor
1	Steam pump	Direct-acting Burnham	1500-gal		Discharging against 180 lb.	Union Steam Pump Co.
1	Steam turbine	Six-jet		Driving Jeansville 1100 gal. turbine pump		Terry Steam Pump Co.
1	Steam pump	Low-service	10 & 14x16-in.	Makeup water		Union Steam Pump Co.
1	Heater	Open	10,000 hp.	Feedwater		Hoppes Mfg. Co.
1	Motor-generator set	Three-wire	500 kw.			Crocker-Wheeler Co.
1	Motor-generator set	Two-wire	150 kw.			Crocker-Wheeler Co.
1	Motor-generator set	Two-wire	75 kw.	Excitation		Crocker-Wheeler Co.

Figuring this cost from the results of the 24-hr. plant test, the steam consumption of the engines and auxiliaries before installing the turbines having been found to be 20.35 lb. per hp.-hr., gives a cost for fuel to produce steam for the low-pressure turbo-generators of approximately $25 per day. Taking the cost of labor at $8.50, supplies and tools at $3, and repairs at $7 per day, gives a total cost for the operation of the turbo-generators of $43.50 per day. Adding to this fixed charges of 13 per cent., on an investment of $120,000 for turbo-generators, condensers, switchboard, etc., or a fixed charge of $52 per day, represents a total daily cost of $95.50 per day for operating the low-pressure turbo-generators. The average output per day, as shown by the test, was 1691 kw. per hour, or 40,584 kw.-hr. per 24-hr. day. Dividing $95.50 by 40,584 gives 0.235c. per kw.-hr. as the total cost of electric power, including fixed charges, as generated by the low-pressure turbines at the present time, with a load factor of 53.2 per cent.

Measure of Damages for Removal of Dam—When a dam is condemned for public use, such as a drainage improvement, the owner is entitled to recover the consequent depreciation in the value of his property to which the dam has been appurtenant, plus the value of the water power lost. But on the condemnation of a dam, which has been used only in the operation of a mill, the owner is not entitled to be reimbursed for profits which might have been derived in the future from the use of the dam in developing electric power, if there was no present intention to provide for such development. (Nebraska Supreme Court, Maynard vs. Nemaha Valley Drainage District No. 2, 143 Northwestern Reporter 927).

ouisville Spray Cooling Pond

At the power plant of the Louisville Cotton Mills, ouisville, Ky., is a compact spray, cooling-pond system, s shown by the illustrations. Fig. 1 is a photograph f the pond and nozzles, taken during the noon hour hen the main power engine was shut down.

el. Humidity 66-30-48 LOUISVILLE COTTON MILLS CO.
ax. Temperature 96 Incorporated
in. Temperature 74 CONDENSING SYSTEM Sept. 2,1913
(Hourly Records)

Time		Temperature of Injection	Temperature of Discharge	Difference	Vacuum	Barometer	Remarks
7 A. M.		88	106	18	26	30-22- 30-10	
8 "		90	111	21	25.75		
9 "		93	114	21	25.50		
10 "		94	114	20	25.25		
11 "		96	115	19	25		
11.45 "		98	116	18	25		
1 P. M.		96	114	18	25.75		
2 "		98	114	16	25.75		
3 "		98	115	17	25.75		
4 "		99	116	17	25.75		
5 "		99	116	17	25.50		
5.30 "		99	116	17	25.50		

el. Humidity 66-88-77 LOUISVILLE COTTON MILLS CO.
ax. Temperature 32 Incorporated Dec. 8, 1913
in. Temperature 19 CONDENSING SYSTEM
(Hourly Records)

Time		Temperature of Injection	Temperature of Discharge	Difference	Vacuum	Barometer	Remarks
7 A. M.		75	102	27	27	30-32- 30-46	
8 "		76	100	24	27		
9 "		75	98	23	27		
10 "		75	98	23	27		
11 "		76	99	23	26.7		
11.45 "		76	100	24	26.5		
1 P. M.		76	97	23	27		
2 "		74	97	23	27		
3 "		75	98	23	27		
4 "		76	99	23	27		
5 "		77	99	22	27		
5.30 "							

The cooling pond is 50 ft. in diameter and 11 ft. eep to the overflow. The brick sides are lined with oncrete; the bottom is also of concrete. In case of fire he pond water can be used to supply the mill automatic prinkler system.

The outside spray nozzles are set in semi-ring headers of 24-ft. radius, made up of $2\frac{1}{2}$-in. pipe at each plugged end, with a 7-in. pipe connecting with the 12-in. supply main, and intermediate pipe sizes, as in Fig. 2.

In the center of the pond is a circular header into which eight branch pipes are screwed, four 5-ft. and four 10-ft. long. The header is supplied with water through a 7-in. line connecting with the cross fitting of the 12-in. supply pipes. These branch pipes each carry a 2-in. spray nozzle, placed vertically at the outer end. The 16 two-inch nozzles on the ring headers are placed at an

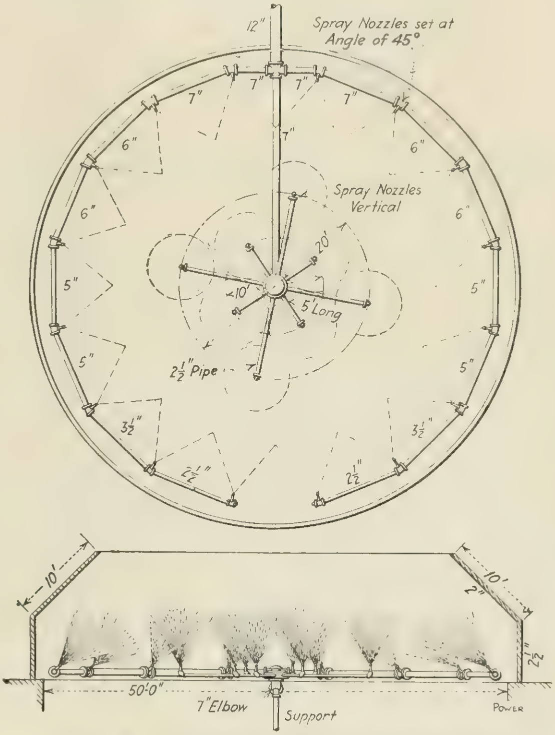


FIG. 2. PIPING OF SPRAY COOLING POND

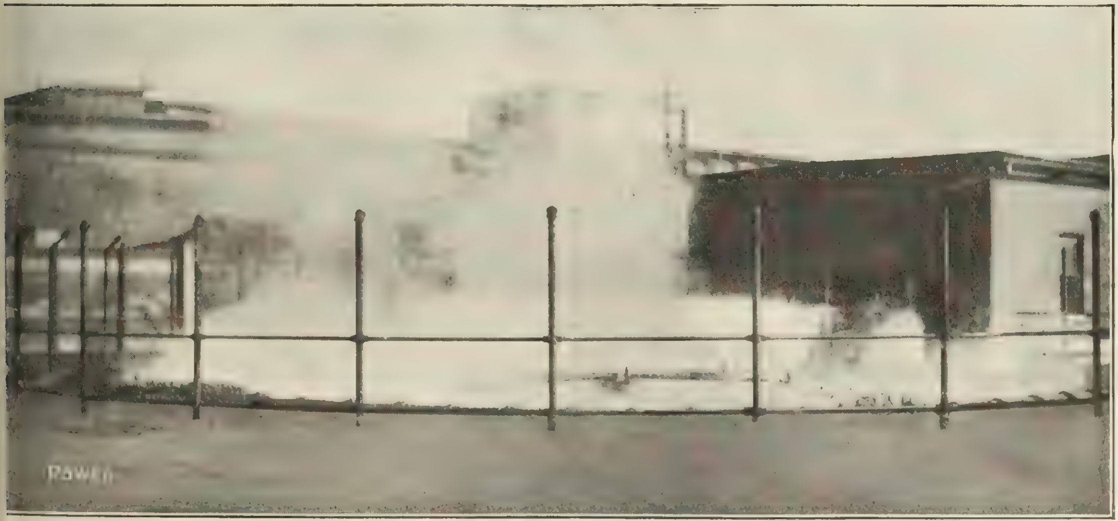


FIG. 1. SPRAY NOZZLES IN ACTION UNDER LOW HEAD

angle of 52 deg. The center circular header is secured to a 7-in. elbow to which a support is screwed.

To prevent a loss of water in the form of spray, the pond will be surrounded with a pipe framework of 30 vertical, 2½-in. pipes, 7 ft. high, the upper end of each being fitted with a 45-deg. ell into which 10-ft. lengths of 2-in. pipe are screwed. These upper pipes will be covered with wood sheathing to catch the spray.

These spray nozzles cool the condensing waters for a 26 and 52 by 48-in. cross-compound Corliss engine. The water is pumped by a 20 and 30 by 20-in. Dean Bros. vertical jet condenser. The suction pipe connecting the condenser and pond is 10-in. in diameter; the discharge pipe is 12 in. Water is forced through the Schutte & Koerting ⅝-in. spray nozzles at between 7 and 9 lb. head.

At the time of the writer's visit, the temperature of the water returning to the nozzles was 102 deg., with a 27-in. vacuum; the water returned to the condenser at 80 deg. During the summer months the average vacuum carried is 25 in. with a discharge-water temperature of 110 deg. and a return temperature of between 90 and 95 deg.

In the data sheets, Fig. 3, is shown the readings of extreme atmospheric conditions with hourly readings of temperature, etc. Thanks for the foregoing are due John T. Hebden, chief engineer and master mechanic, under whose direction the equipment was installed.

* * *

Soot in Relation to Boiler Economy

By F. W. Linaker

The article on the effect of soot on boiler economy by E. D. Fisher, in Power, Dec. 9, 1913, was of interest, but his experience with soot as affecting the efficient and economical operation of a boiler plant is not in accord with either the generally accepted views or the writer's experience.

The article states that test *A* was run one week after the tubes had been thoroughly swept and the boiler operated as usual without blowing or cleaning the tubes. Test *B* was run two weeks after test *A*, and one week after the tubes had been swept, the boiler being operated as usual and the tubes blown daily. The tests were of two hours' duration, and were started and stopped by the alternate method.

In a test of but two hours' duration almost any results that the operator might desire could be obtained, but to get dependable results in so short a run would be impossible. The condition of the boiler, and the method in which the tests were conducted, would lead to gross inaccuracies, and, as this is a common fault among observers making tests to determine the relation of soot to boiler efficiency, this is an excellent opportunity to call attention to the cause of these inaccuracies.

A well designed soot blower is intended to keep the heating surface of a boiler in a clean condition indefinitely, if used daily, provided the heating surface is thoroughly cleaned to start with. A blower that is capable of keeping the tube surface in a clean condition may not be capable of digging up old deposits of soot and ash that have accumulated in the past, and may be so caked and packed in nooks and corners as to resist blowing of any kind, especially where the ash has had opportunity to fuse and run, forming a more or less solid mass. When such conditions exist no blowing device can do itself justice.

In making comparative tests the heating surface should be thoroughly swept and cleaned before each test. Then after a week's or a two weeks' run, with either method of cleaning employed, the boiler can be considered to be in its average condition. A test conducted in this manner is a real comparative test. If a mechanical blower has to start with dirty and soot-packed boiler tubes it cannot make a proper showing.

In the article referred to, it is stated that a bad feature of soot blowers which require a number of jets piercing the boiler wall is, that the brickwork cracks, and in consequence air leakage through the setting occurs.

One case is cited where it was found, from gas samples taken over the fire in the first pass, that there was 11.0 per cent. CO_2 corresponding with 77 per cent. excess air while in the back connection simultaneously samples showed only 5.8 per cent. CO_2, corresponding to 280 per cent. excess air. Such a drop in CO_2 indicates nothing so far as soot blowers may be concerned, but indicates that the engineer in charge was guilty of tolerating a setting that was little better than a sieve. Anyone experienced in gas-analysis work could mention many cases where the air leakage was far greater than the case cited and where no mechanical soot blowers were installed.

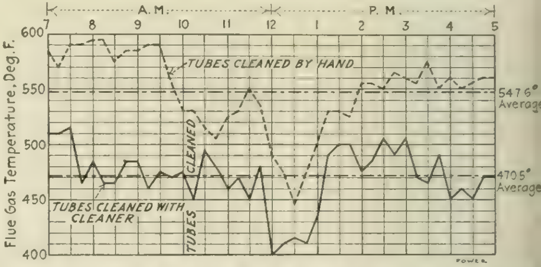


Chart of Temperatures of Flue Gases, with Hand and Cleaner Blown Tubes

This objection to air leakage through the setting may apply to some types of apparatus, but it is a safe guess that from 50 to 80 per cent. of all air leakage into the furnace is through cracks and crevices in doors, between the frames and brick-work, and where the walls are made thinner on account of the blow doors.

There are mechanical blowers, installed independently of the side blow doors, with wall sleeves set solidly into the side wall. These pipes and sleeves can be so cemented into the wall that the setting is tight. Such a blower reduces air leakage, as there are no blow doors to open while cleaning, and it is possible to seal them, when present, in a permanent or temporary manner.

Every time boiler tubes are blown by hand, there is an inrush of cold air that chills the tubes and dilutes the gases. Chilling the tubes will, in time, cause contraction and leakage. Diluting the gases lowers the efficiency. This can be demonstrated by a flue-gas analysis. During the hand-blowing period there will be found a drop in the CO_2, averaging 4 per cent., say from 10 to 6 per cent. CO_2. The sealing of blow doors cannot be too vigorously urged, for air leakage through settings is detrimental to both draft and economy.

On all types of boilers equipped with a properly designed soot blower it is not necessary to use the clean-out doors, except for inspection purposes, and, therefore, a temporary or permanent seal of those doors may be made, thus insuring a tight setting. These simple precautions are bound to increase the CO_2, in some cases as much as 4 per cent.

To illustrate the tightness of settings obtainable with some soot-blowing systems one of the largest electric-power plants in Detroit is equipped with a certain soot-blowing outfit which has been in use for the past eight years on 50 boilers, a total of 31,250 boiler horsepower being equipped, together with blowers for the economizers.

The plant runs with an average of 14 per cent. CO_2. The engineers say that they could increase their CO_2 if they desired, as during one test made to determine the efficiency of different styles of baffling on a boiler equipped with this soot-blowing device they obtained 17 per cent. CO_2.

These figures show that a well designed soot blower, properly installed, is not the cause of air leakage, but rather goes hand in hand with a tight setting.

The accompanying record is taken from the manufacturers' catalog, and is of a test made to determine the efficiency of the type of soot blower above referred to. The figures of the record have been verified by inquiries at the plant of the Champion Coated Paper Co., Hamilton, Ohio, where this test was made. They were made on a horizontal water-tube boiler. Test No. 1 was taken before the soot cleaner was installed; test No. 2 after the soot cleaner was installed.

	Test No. 1	Test No. 2
Duration of test	10 hr.	10 hr.
Average steam pressure	150 lb.	151 lb.
Average temperature of water to economizer	167°	172°
Average temperature of water to boiler	253°	219°
Coal as fired	20,929.5 lb.	18,661 lb.
Water evaporated	199,686 lb.	191,671 lb.
Ash	11%	11.7%
Moisture	0.86%	0.69%
Equivalent evaporation of water per lb. coal with economizer	10.5 lb.	11.36 lb.
Equivalent evaporation of water per lb. coal without economizer	9.62 lb.	10.76 lb.
Gain for economizer	8.76%	5.28%
Average temperature of gases to economizer	669°	502°
Average temperature of gases to stack	500°	384°
Horsepower developed	601	610
Percentage of boiler rating	200	205
Average CO_2	Not taken	13.5%
Draft entering economizer	0.2 in.	0.2 in.
Calorimeter test	12,171 B.t.u.	14,279 B.t.u.

The foregoing tests show a gain of over 7½ per cent., for which the credit is due to the soot-blowing apparatus, as the tests, as far as possible, were run under otherwise identical conditions. Unfortunately the CO_2 was not taken when this boiler was cleaned by hand, but the percentage of CO_2 when the soot blower was in use was 13.5 per cent., which shows that the settings were in excellent condition. The stack temperature shows a reduction of 116 deg. F.

An engineer with an eye for economy looks carefully after his boiler setting so as to reduce the air leakage to a minimum. The practice of encasing the whole setting in steel is excellent and is increasing, but engineers realize that there is a greater gain if the blow doors are also encased, as it is practically impossible to keep these doors air-tight. To overcome this difficulty, it has become common practice to omit the dusting doors and steel case the entire setting, and install some type of mechanical soot blower for cleaning the boiler tubes.

One of the largest New York companies recently installed thirty-two 600-hp. horizontal water-tube boilers, 14 tubes high by 21 tubes wide. These boilers are steel cased with no provision for hand cleaning. The boilers are cleaned by means of a mechanical soot-blowing system, consisting of eight 2-in. blow pipes, which extend across the width of the boilers. Four of these pipes are at the top of the first pass, two at the top of the second pass and two at the top of the third pass. Each pipe is equipped with special three-way nozzles drilled so as to project the steam obliquely between the tubes. The nozzles on alternate blow pipes project the steam down through the space between the tubes on intersecting planes and between different pairs of tubes, so that the steam crossfires over the heating surface. An additional 2-in. pipe with smaller branch blow pipes cleans the superheater.

In the article under discussion the statement is made that the worst feature of all forms of fixed-jet apparatus is that they cannot be spaced close enough to effectively clean the tubes. This statement seems hardly in keeping with the evidence at hand. The foregoing tests indicate that the soot blowers reach considerable soot that is inaccessible to hand blowing.

Many of the most progressive power plants in the country, especially in the electric-light and railway field, have been using mechanical soot cleaners for years and have placed repeat orders until every boiler is equipped with such blowers, which is evidence that the cleaners must be real soot removers.

The fact that users of the latest improved soot-blowing systems do not go within the settings to remove soot by hand would further indicate that such blowing systems are efficient. In the case of hand blowing, however, it is always necessary to resort to such periodic cleanings, which, as Mr. Fisher states, is an acknowledged failure.

One of the main troubles experienced in trying to blow soot from boiler tubes by a hand steam lance is the impossibility of using one long enough to reach across the boiler. This results in the soot piling up on the tubes at the far side of the boiler. With the boilers set in batteries, as is the usual practice, it is impossible to overcome this difficulty when blowing the tubes by hand. Even where it is possible to use a lance across the boiler width, this blowing does not clean the sides of the tubes, which play an important part in the evaporation of water.

The soot clings to the tube side, defying removal by hand blowing, and the soot on the tops of the tubes at either side of the blow doors remains untouched. The bulk of the soot that is reached by the hand blowing is really not all removed, but is stirred up and a portion settles on the tubes again. Cleaning the top of a tube prevents some waste, but a properly designed soot cleaner cleans the whole tube surface and is much more efficient.

To further illustrate the losses occasioned by soot on boiler tubes the results obtained at one of the largest electric plants in the country are as follows: Starting with a clean 600-hp. horizontal water-tube boiler at 50 per cent over rating, the gas temperatures in the uptake were:

	Degrees
First day	550
Second day	575
Third day	600
Fourth day	625
Fifth day	650

These boilers had no blowing system, and in fact were not even blown by hand, and the increase in uptake temperature is significant.

Another test which emphasizes even more strongly the importance soot plays in relation to boiler efficiency, and also illustrates the efficiency of the mechanical soot blower employed, was conducted by recognized engineers at one of the largest electric-lighting plants in the Middle West.

On a new 750-hp., water-tube boiler, never before fired, the tubes were blown at the end of the first hour's run and immediately there was a drop of 20 per cent. in the uptake temperature. Twelve hours later the tubes were again blown and a drop in the uptake temperature of of between 65 and 70 deg. took place. These figures show the effect that soot has on boiler efficiency and also show the importance of frequent and thorough cleaning.

Mr. Fisher states that with good firing a reduction of 50 deg. F. in the flue temperature will mean a saving of 3 per cent. in the coal bill. In connection with this statement, which is acknowledged to be approximately correct, it will be interesting to study the accompanying chart, which was taken at one of the largest cotton mil in Massachusetts.

During the afternoon of the day of the test, exper ments were being made with a new grade of coal and ne methods of firing, in consequence of which the readin of temperature during the afternoon were errati However, accepting the average as shown by this chart, will be seen that the soot-blowing device, while not recei ing all credit due it, still shows marked economy. On th boiler equipped with the mechanical soot blower the cha shows an average reduction in uptake temperature of deg. F. in comparison with the boiler cleaned by han This 77 deg. F. reduction represents a 4.6 per cent. savi in fuel. Who would question if the money expended f that soot blower is paying a dividend?

Mechanical soot blowers have been in process of develo ment for the past 10 or 12 years, during which time mu valuable experience has naturally been gained by t pioneers in this field. Soot cleaners installed witho the proper experience or design back of them can hard be expected to give the best results, but to include types of soot blowers under a general condemnation is t sweeping.

Most engineers admit that soot defies removal by han blowing. It is generally admitted that the mechanic blower correctly designed, properly installed and intel gently operated is the real solution to the soot proble

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Calculating Power in Alternating Current Circuits--III

By Norman G. Meade

SYNOPSIS—The use of synchronous motors for improving the power factor, and the characteristics of such machines.

⁂

So far, the causes and effects of leading and lagging currents have been considered and reasons given why the power factor should be maintained as high as possible. has already been stated that synchronous motors can used to correct lagging currents. Before taking up th feature it may be well to study the characteristics of su machines.

In construction synchronous motors resemble alterna

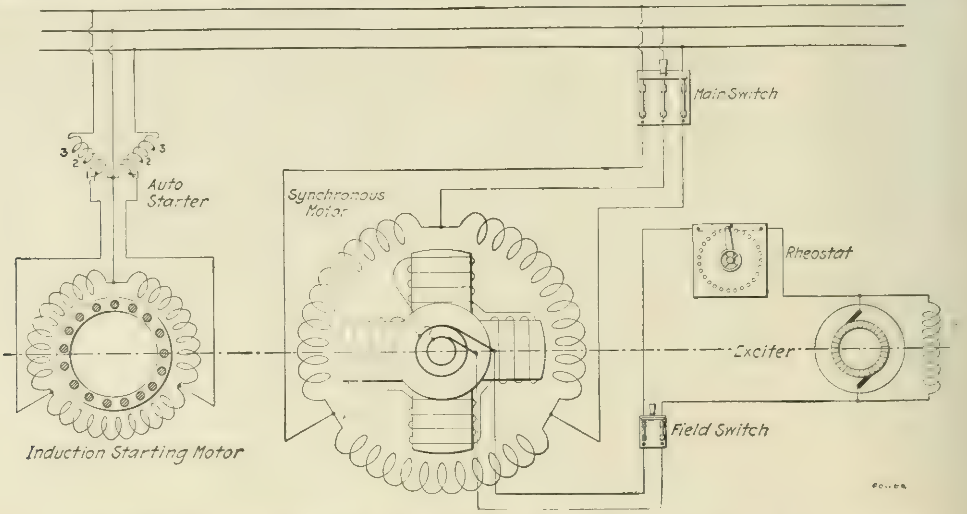

Fig. 15. Connections of a Two-Phase Synchronous Motor with Its Starting Motor and Excite

ing-current generators, and they are usually of the revolving field type. The fields are excited by direct current generally supplied from an exciter belted to or directly connected to the motor. A synchronous motor will run in synchronism with a similarly constructed alternator after it is brought to the same speed, or, if the number of poles in the two machines are not the same, to some multiple of the speed of the generator, provided the number of pairs of poles on the motor is divisible into this multiple. Such motors will operate as though geared to the generator even up to two or three times their normal full torque capacity.

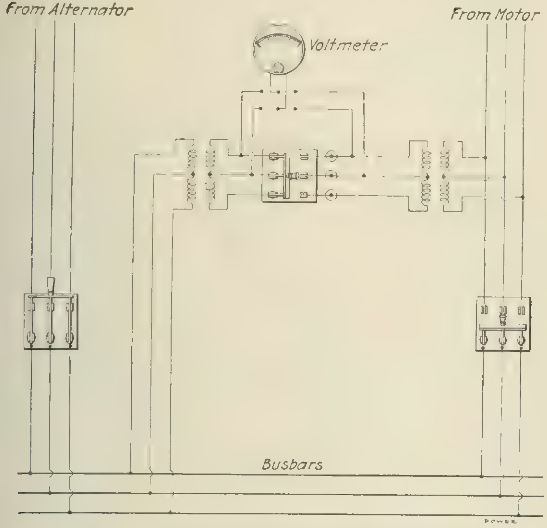

FIG. 16. CONNECTIONS FOR SYNCHRONIZING

Polyphase synchronous motors (single-phase synchronous motors are rarely used) will come up to synchronism, giving about 25 per cent. starting torque, when started as induction motors with the field open.

When connected to lines with an inductive load overexcitation of the motor field acts in the same manner as a condenser introduced into the line, and tends to restore the current to phase with the impressed electromotive force and, therefore, do away with inductive disturbances.

Two general methods of starting synchronous motors are in use, namely, by a separate starting motor, or by self-starting. Where the machine is single-phase, a direct-current motor is usually employed for starting, but where polyphase current is used the starting motor is usually of the induction type.

In self-starting, the application of alternating currents directly to the stationary armature without field excitation, will result in a rotating magnetic field about the armature core. The eddy currents thereby produced in the pole faces will exert a torque on the rotor and will cause it to speed up to synchronism. Usually a starting compensator is employed for reducing the applied electromotive force during the starting period.

When starting synchronous motors the field is open-circuited. In practice the field coils are connected in various ways to obviate the danger of high induced voltage. One way is to use a low-voltage excitation and few turns on the field coils, or the field coils may be split up by a switch at starting, and when the motor reaches synchronous speed the excitation is thrown in.

The use of a separate starting motor is especially advantageous with synchronous motors, for with self-starting large lagging currents are taken from the line. Since the induction motor must have some slip, it is necessary in order to bring the synchronous motor to full synchronism, that the starting motor shall have fewer poles than the main motor. Fig. 15 shows the principal connections of a two-phase synchronous motor with its starting motor and exciter.

Before a synchronous motor can be put into service it must be brought up to synchronous speed and into step with the supply system. Some methods of indicating synchronism must be employed before the main motor switch is thrown in, when the synchronous motor is started by a separate starting motor. The common method is to use incandescent lamps, or a synchroscope as in synchronizing alternators. The connections are shown in Fig. 16.

Care must be exercised in the use of synchronous motors and their best condition of operation is when the load is quite steady, otherwise they introduce effects on the line that are quite troublesome. The field of such a motor can be adjusted for a particular load, so there will be neither leading nor lagging currents, but unity power factor. If the load changes, then the power factor also changes, until the field is readjusted. If the current has been lessened then the current will lead, but if it increases the current will lag.

If two or more synchronous motors are connected to the same circuit, and the load on one is variable, and its field is not changed to meet the changing conditions, a hunting effect is likely to take place in the other motors unless special provision has been made to prevent it.

Assume that the load on the generator suddenly varies to a considerable extent, when a large load is suddenly thrown off. The generator will tend to speed up. The motor naturally will follow this increase in speed, but the inertia of its moving parts will cause an instantaneous lag in the speed and the two machines will be slightly out of step, causing cross-currents to circulate between the two machines. The motor will come up to synchronous speed, but the effects of inertia are still present and it will run ahead of synchronous speed, causing cross-currents to be set up again. This oscillation will take place for a few seconds. The effects of hunting are minimized by placing copper grids in the pole tips of the field poles.

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Electrical Instruction for Pennsylvania Employees—In announcing that it will establish schools of electrical instruction for its employees at Conemaugh, Derry, Gallitzin, Cresson, Pitcairn and Pittsburgh, the Pennsylvania R.R. has given rise to the report that the intention is to electrify the Pittsburgh division, which extends from Pittsburgh to Altoona, a distance of 119 miles. In this stretch is the big mountain range at the summit of which is the Gallitzin tunnel and at the eastern end of the tunnel begins the big descent that is known as the famed "Horseshoe Bend." This 119 miles from Pittsburgh to Altoona is considered one of the most difficult problems in steam railroading in America. Should the Pennsylvania install electric power on this division it would be only a question of time until the entire system would be electrified. The Pittsburgh division is the really big problem with the Pennsylvania Railroad. The new schools are to be equipped with all the apparatus used in the electrical operation of trains and the various phases of the method will be explained in theory and practice. Among transportation men in Pittsburgh this move by the Pennsylvania is regarded as peculiarly significant.

How a CO_2 Recorder Works

By Charles H. Bromley

SYNOPSIS—Telling in a simple way how and why a CO_2 recorder is able to record the percentage of CO_2 in the flue gases.

◆

When you use a sponge to soak up water from the floor you do not consider that anything remarkable has happened. You have seen the tanks at the gas works rise as they filled with gas, and drop down as the gas was discharged, and you thought that a usual proceeding.

The principal reasons why a CO_2 recorder records CO_2 are really no more mysterious nor remarkable than the absorption of water by a sponge, or the inflation of a tank by gas. Practically, the same physical actions occur in both cases, but the things we use are different.

Because chemicals have unfamiliar names, is no reason why we should shy at them any more than we shy at a yeast cake, which is a chemical. Some chemical solutions absorb certain gases just as a sponge absorbs water. You know that to relieve a gas-bound ammonia pump you let the gas discharge into a pail of water. If the gas were discharged into the room the fumes would be quite disagreeable, but when discharged into the water the gas is absorbed like water by a sponge.

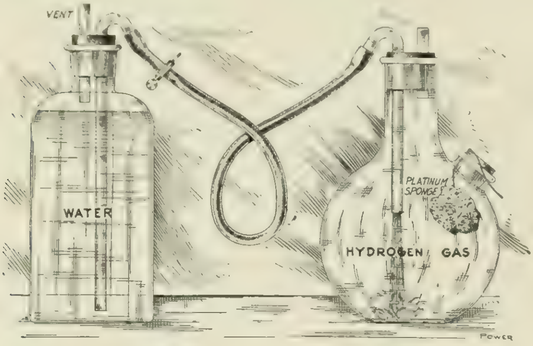

Fig. 1. Absorption of Gas by Platinum Sponge Creates Vacuum in Bottle

Platinum sponge will absorb a surprisingly large amount of hydrogen gas, and the sponge will not increase in volume. To prove that it will absorb this gas we will arrange two bottles, as in Fig. 1. One is filled with water, the other with hydrogen gas. We suspend a piece of platinum sponge in the gas as shown. The sponge will then absorb the gas, create a vacuum in the bottle and draw into it water from the other bottle.

The first experiment showed that some substances do absorb gas. We will now experiment with a sample of flue gas of 100 c.c.; 12 per cent. is CO_2 and the other 88 per cent. is made up of other gases.

We have four bottles, Fig. 2, one containing 100 c.c. (cubic centimeters) of water; one, 100 c.c. of flue gas; one with a caustic-potash solution and the last bottle we will consider inverted and full of water. Opening the pinch cocks on the rubber tubes connecting the bottles, lift the water bottle to the position indicated by the dotted lines. The water flows into the second bottle, forcing the 100 c.c. of flue gas out, causing it to bubble up through the caustic-potash solution. After the gas has passed through the solution, an analysis would show no CO_2, but it would show that 88 c.c. of other gases were present. At the beginning of the experiment the inverted bottle is filled with water and is sealed by a little water in the jar, just as the spring-water-bottle drinking fountains are arranged. If the flue gas contains 12 per cent. CO_2 and this bottle is lifted as the gas comes into it, so that the water levels in the jar and bottle are the same, the

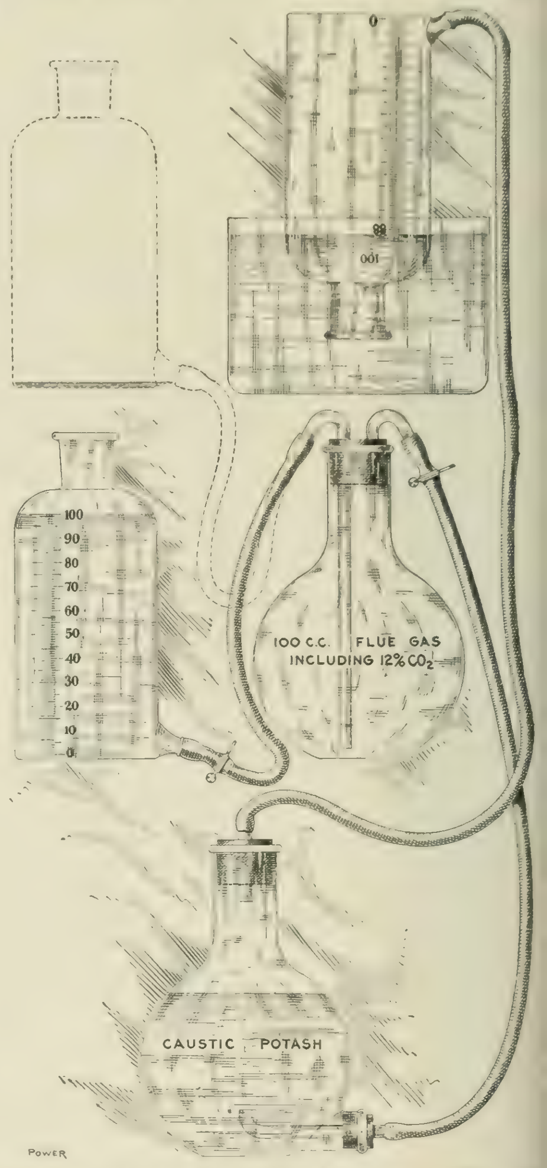

Fig. 2. The Caustic Potash Absorbs the CO_2, but the Other Gases Pass On

water will run down to the 88 c.c. or per cent. mark and the gas will be at atmospheric pressure, as it has been throughout the experiment. The other 12 per cent. of the gas or the CO_2 did not get through the caustic potash.

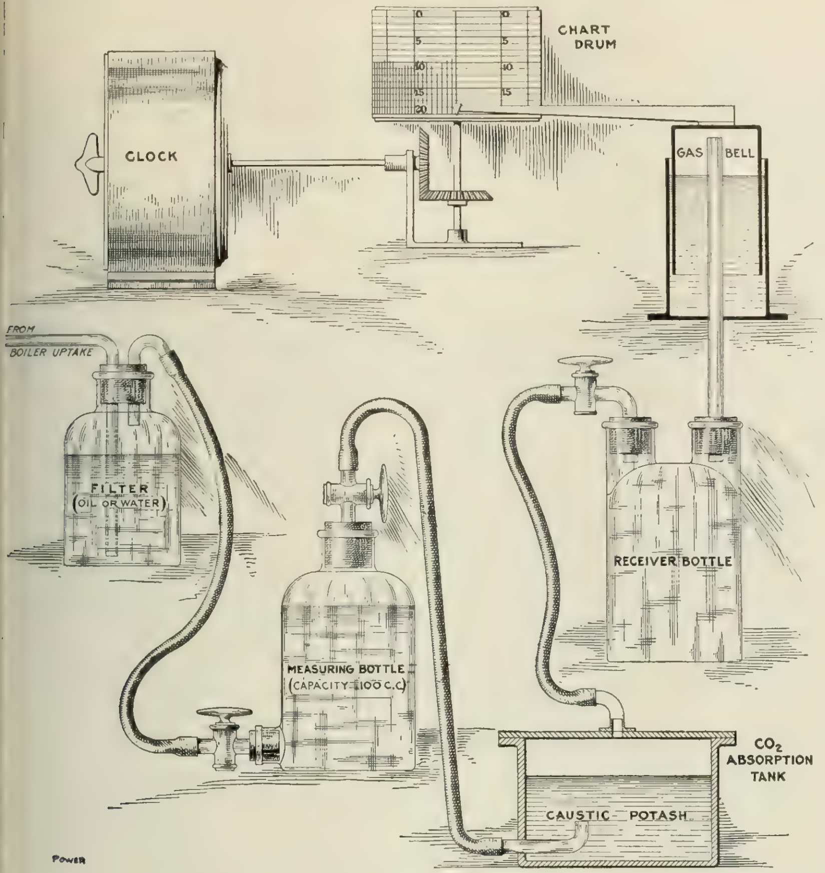

Fig. 3. Here, in Simple Form, Are the Essentials of a CO_2 Recorder

This experiment demonstrates that a caustic-potash solution absorbs only the CO_2 in the flue gases but allows the other gases to pass through. About the same process as that gone through in this last experiment goes on in a CO_2 recorder.

In the recorder the chemical or "sponge" which absorbs the CO_2 is caustic potash. The pen which marks the chart is attached to the top of a gas bell that rises and falls as it is filled with and emptied of the CO_2 gas, just as the tanks at the gas works rise and fall.

Before continuing, let us understand why we say such and such a percentage of CO_2. Percentage means "by the hundred," and 10 per cent. or 12 per cent. means 10 or 12 parts of a total of 100 parts. The total of 100 parts, or 100 per cent., may be any quantity we choose to make it. In measuring CO_2, all or 100 per cent. of the sample of gas taken from the flue is 100 cubic centimeters (c.c.), or a little over 6 cu.in. When the flue-gas analysis shows 12 per cent. CO_2 we know that 12 parts, or 12 c.c., of the 100 parts, or 100 c.c., is CO_2 gas.

Fig. 3, shows the essentials of a CO_2 recorder, and when you understand it, you will understand how and why any CO_2 recorder works. The gas is brought from the boiler uptake and passed up through the filter, which contains a bottle nearly filled with oil or water to take out the soot in the sample. Gas flows into the measuring bottle, which holds exactly 100 c.c., or about 6 cu.in. The sample having been measured, it goes to the "sponge," or caustic-potash solution, where all the CO_2 gas is absorbed, and the rest bubbles through the solution and fills the receiver bottle. From the receiver bottle the gas is led to the gas bell, which has a water seal so that gas cannot escape to the atmosphere. This bell and the pen arm rise and mark the chart against which the pen bears. When the mark is made the gas goes back through the pipe *A* and eventually goes to the atmosphere. The chart drum is revolved by clockwork, as usual.

As the caustic potash absorbs only CO_2 we see that if the measured sample is high in CO_2, there will be less gas going through the solution to fill the gas bell, and the pen will not make as long a mark as when more gas is passing through the solution. On a recording steam gage or thermometer the pen makes a longer mark as the pressure or temperature increases from the zero point on the chart. This is not so with the CO_2 recorder of this sort. The greater the CO_2 percentage, the shorter the mark.

To get the gas into and out of the measuring and receiving bottles, caustic-potash tanks, gas bell, etc., many siphons and traps are required. The motive power for most CO_2 recorders is a stream of water flowing from a pet-cock. As the stream is increased the machine works faster; that is, it makes a greater number of readings per hour. With the usual CO_2 machine about seven or eight readings per hour will produce a good chart.

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Short-Circuit Test of Large Generator

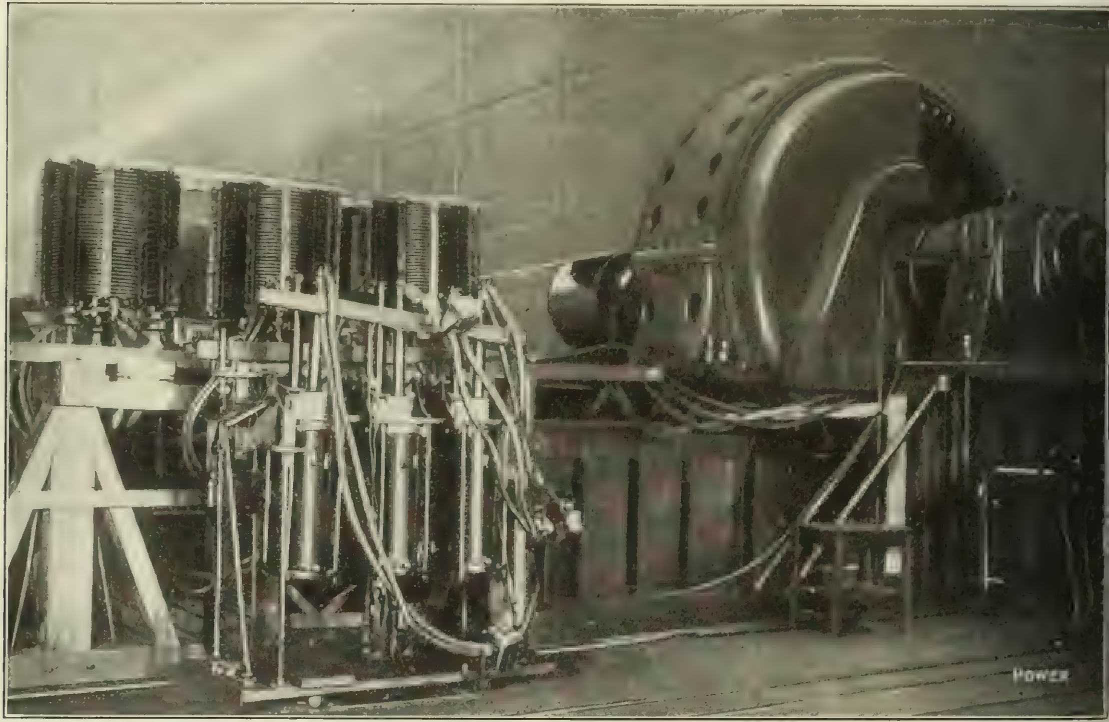
The photograph shows a 16,700-kv.-a. generator connected for a short-circuit test at the Westinghouse Works, East Pittsburgh. The test was made in the presence of representatives of electric companies, and the machine, running at full speed and generating current at 8800 volts without resistance or any other protection in the circuit, was deliberately short-circuited. Oscillogram records showed that a current of 21,000 amp., or 12½ times normal, flowed through the generator.

Such a test would have wrecked a generator designed some years ago, but in the present instance no damage whatsoever was done. The only visible effect was a static flash between the field and the armature. The test was performed to prove that generators are being built requiring no protection from outside short-circuits, the generator itself being so designed as to be self protecting. The destructive effects of a short-circuit are guarded against by firmly securing the armature coils and bracing their ends, and by the use of mica insulation.

In connection with this test, several others are carried out in order to prove the reliability of circuit-breakers and reactance coils for protecting the feeder circuits. The generator was repeatedly short-circuited through these devices which stood up under the enormous stresses to which they were subjected.

The practice recommended by the Westinghouse engineers is to perfect the feeders and not the generators. If the generators are protected and a short-circuit occurs on any of the feeders, even a poorly designed generator will not suffer, but the voltage will fail on all the feeders, all synchronous motors will be thrown out of step, and an overwhelming overload will be thrown on the circuit-breaker of the short-circuited feeder, since it will carry the total current of all the generators in the station. If, however, protective reactances are placed in each feeder circuit, and a short-circuit in a feeder occurs, only that feeder will be affected and even then its reactance coil will prevent the current in it from rising to too high a value. The voltage will be maintained at the busbars and no disturbances will be felt in the remaining feeders.

While it is possible to protect non-self-protecting generators by reactances, this is unnecessary since generators can be supplied that are immune to the worst conditions of load that can be imposed upon them.



Large Generator Undergoing Short-Circuit Test

Recent Court Decisions

Digested by A. L. H. STREET

Risk Assumed by Engineer—An engineer at a power pla assumes the risk of being injured through breaking of ladder which he is required to use, so far as concerns defe which an ordinarily prudent employee would discover in th same circumstances. (Indiana Appellate Court, Beard v Goulding, 102 "Northeastern Reporter" 8.)

Performance of Dam Construction Contract—Where a co tract for the construction of a dam requires the core wall be extended down to and into impervious materials, but th drawings, which are made a part of the contract, prescri a certain depth at which the wall is to be constructed, th contractor is not bound to extend the wall below the lim fixed by the drawings, although impervious material is n reached at that depth, he being entitled to assume that th depth fixed by the drawings was established after examina tion of the earth on the site of the dam. The contractor rights in this regard are strengthened by the supervising en gineer's acquiescence in the manner in which the work constructed. (United States Circuit Court of Appeals, Nint Circuit; Continental & Commercial Trust & Savings Ban vs. Corey Bros. Construction Co.; 208 "Federal Reporter" 976.

Power Company as "Manufacturing" Corporation—A pr vision of the Minnesota constitution makes each stockholde in any corporation, except those organized for the purpose o carrying on any kind of manufacturing or mechanical business, individually liable for the debts of the corporation t the amount of stock held or owned by him. Feb. 13 th Supreme Court of that state held, in the case of the Vencedo Investment Co. vs. the Highland Canal & Power Co., of Duluth, that a corporation organized for the purpose of generating electricity for distribution to the public is a "manufacturing" corporation within the meaning of the exemptio contained in this constitutional provision. The court decide that this conclusion is not to be affected by the fact that th corporation is vested with the power of condemning land i conducting its business. The opinion recognizes the fact tha it is not in harmony with decisions in other states, bu follows a Minnesota precedent, reversal of which the cour says "would result in imposing a liability the stockholder did not intend to assume and create rights in creditors the had no right to expect or rely on."

Editorials

Designing Isolated Plants for Economical Service

The critical study of isolated-plant design is interesting and profitable. Scrutinizing new installations from the standpoint of the efficiency expert, to see how the design of the plant might have been bettered, is good practice.

An engineer, given the privilege of going over a large isolated plant, followed this course, and, without detracting from the good features of the design, noted for his own benefit the points which seemed defective in the installation.

The boiler room was about 50 ft. below the street, yet the architects, or whoever was responsible, failed to grasp the possibilities of gravity-coal delivery from the bunkers directly into the stoker hoppers. Instead, the fuel was delivered into hand cars from spouts near the boiler-room floor level, wheeled through a narrow doorway, dumped from the cars and shoveled by four coal passers into the stokers which were about 5 ft. above the floor. The cost of getting the coal from the spouts to the hoppers was $426 per month.

The visitor learned that a mechanical conveyor, about to be installed at a cost of $4200 to overcome the disadvantages of the original design, would save the owners $2572 per year, allowing 20 per cent. for fixed charges and operating costs. Adequate appreciation of boiler-room necessities in the first place rather than so much attention to the exclusively ornamental features by the architects would have meant lower annual costs for the owners.

In another case the efficiency of an isolated plant was found to be much lower than might have been expected on account of a large installation of indirect lighting fixtures, every pair consuming nearly a kilowatt, and some of them being operated ten hours a day. As a result a surplus of exhaust steam over that needed to heat the building was being wasted. Probably purchased current for such long-hour lighting business would have meant a lower total yearly expense. A heavy sustained lighting demand from morning until night is attractive to the central station, and such installations are giving the student of power economics food for thought.

Nothing is more important in the design of an isolated plant than the number and capacity of generating units selected. In a certain plant, there are five generators having a combined capacity of 1350 kw., or nearly twice the maximum demand. The visiting engineer noticed that the load averaged about 600 kw., the peak seldom exceeding 700 or 800 kw. Evidently, omitting one 300-kw. unit and its auxiliary plant would have saved nearly $15,000. Further, the engines were often run at part loads to avoid water in the cylinders arising from another defect—improper drainage of the steam lines. It appeared to the observer that the plant would do excellently with three generators of 750-kw. total rating, devoting one 150-kw. and one 300-kw. machine to the lights and a 300-kw. generator to the power load, the average lighting load being 370 and the power load, 200 kw.

Practical studies of this kind are helpful to the engineer who may some day be called upon to estimate the loads and equipment desirable for his employer's new plant. Over-powered isolated plants, with little likelihood of growth, may not cost the owner as much to maintain in yearly service as under-powered layouts, but they are none the less a source of excessive expense and deserve space in the personal note book of the visiting engineer when he is studying what to avoid in plant design as well as what is worthy of imitation.

Fairness to Understudies and Successors

No better test of the caliber of an engineer can be applied than to put him where he can treat both understudies and successors according to his own free will. Granted that there are many occasions where an engineer has every provocation to quit his work without lifting a finger on behalf of the future welfare of an ungrateful or unreasonable employer, it none the less follows that the man who can rise above these sources of irritation and give the best that is in him to the plant to which he has devoted himself so long as he is in a position to help matters, shows himself far superior to the fellow who nurses a grudge, and definitely raises the tone of his calling by his coöperative spirit. The treatment of understudies and nominated successors often calls for a large measure of tact and magnanimity, but there are so many practical ways of lending the helping hand to both classes of individuals that there is seldom much need of dwelling upon the trying phases of the situation from the emotional standpoint.

When an engineer realizes, either through his own choice or through circumstances, that a successor is slated for his position, and after he has made his own arrangements for taking up work elsewhere, there is often an interim of weeks or months before the change comes, and often the man who is going to leave has the opportunity to become somewhat acquainted with the chap who is to follow him. If an understudy is to take up the work, the opportunities for assisting the incoming man are sure to be numerous, unless through long assistance and apprenticeship the details of the plant are practically as familiar to one as to the other. Whether the new engineer comes from outside or inside the organization, the retiring man of the right sort will throw open every detail of his knowledge of the physical plant in his charge to his successor; he will show him upon request, or after an appreciated suggestion, the purpose and special features of all parts of the equipment which might be difficult to handle or understand quickly; and he will share with the new engineer every proper record of operation which he himself would desire to have in taking charge of the installation. If the new man desires to make a list of all machinery sizes, such as cylinder diameters and strokes, capacities of pumps, heads and pipe sizes, he will throw open his notebook for his benefit and will permit blueprints to be made of tracings which he may have, besides explaining freely the manner of operation of any home-made labor-saving or other devices for enhancing economy of operation for which he may have been responsible.

He will share the results of tests and will post his successor, so far as the latter shows himself a suitable person to be posted, upon the general policy of the organization regarding purchases of fuel and supplies, the treatment of inspectors and public officials, and the existing division of responsibilities among his subordinates. The wise engineer will consistently avoid personalities, however, either in speaking of his superiors or of those under him, and thus will leave the incoming engineer free from prejudices and in a position to form his own judgments of his associates. If a man can make himself grant this sort of coöperation with an utter disregard of his own personal likes and dislikes in relation to those above and below him, he deserves to be classed among the thoroughbreds and listed as a master of his own personality, no less than of his highly technical and responsible profession.

The Engineer's Training

It is a much discussed subject whether a technical education and training really pay the engineer. A man who has acquired his knowledge in the shop or power plant from the ground up is frequently of greater value to his employer than a man of equal degree of intelligence who has spent the same time in acquiring a technical education and passing through that period of employment during which he finds that his knowledge must in great part be forgotten and knowledge of the system and practice of his employer acquired in its stead. At some period in the development of the two men their value to those for whom they work will become equal, after which the trained man may or may not outstrip the other. If the engineering ability of the technically trained man has been made sufficiently subservient to his new environments, and his conceptive faculties thereby dulled, it still remains an open question whether the other man may not finally outdistance him. Should his engineering ability remain unimpaired and during his practical training should he have been able at times to take the initiative, he will probably grow much more valuable to his employer than the man trained entirely in the shop or plant.

The large manufacturers fully realize this, as is evidenced by the number of technically trained college men to whom they give employment each year, but this does not alter the fact that the natural effect of employment by a manufacturer is to lessen the engineering ability of the trained engineer. A doctor's assistant who had spent, say some seven years in assisting a surgeon in amputating limbs and finally performing the operations himself, could cut off a man's arm more efficiently and satisfactorily than a young doctor who had just completed his seven years training, but if treatment was required for a sprained wrist, for instance, the sufferer would probably prefer to go to the young doctor than to trust to this specialist in limb removal. Even the employer of the assistant would probably choose the young doctor to help in a case not identical with the assistant's regular duties.

The engineer's livelihood depending upon his ability to make good, his responsibilities are great and his place in the modern industrial world important. Economy and efficiency are impossible without his applied knowledge and it seems strange that his economic value is not more generally recognized. To be a consulting expert, the engineer need not necessarily be a college-bred man, as in almost every other profession, but the college man ordinarily has the advantage, for without definite and legal requirements for the right to pass as an engineer some standard must be adopted. An engineering degree conferred by a technical school of repute naturally carries considerable weight. No such degree can be obtained from a technical school of recognized high standing without the recipient acquiring at least a knowledge of the principles of good engineering. Though engineering is but "good horse sense" and can be acquired without going to college, the man *not* trained in a technical school must have a past record and his experience must have been general and more exacting than that of the college man, in order to develop to the same degree those powers of perception and resourcefulness afforded the college man by his technical training—a technical education at college being but a short cut for developing powers of perception and ability to diagnose correctly.

Hands Off!

Again the politicians seek to interfere with the work of a semi-engineering department well and efficiently conducted.

The work of Lewis T. Bryant, Commissioner of Labor for New Jersey, is looked up to by many authorities as most commendable.

The New Jersey Labor Department has to do with factory inspection, which includes hygiene, building and electrical inspection, and the enforcement of the child-labor law. It must also enforce the recently enacted engineers' license law.

Governor Fielder has retained Mr. Bryant, and the cheap politicians are uneasy. The Economy and Efficiency Commission, authorized to probe the affairs of state departments, apparently seeks to discredit and embarrass Commissioner Bryant, and plans to wipe out his department by combining it with the department of Statistics of Labor and Industry, with the intent, perhaps, of procuring soft berths for some of its friends. It is the same old story, and another example of why such a department should be severed from political influence.

The Bureau of Engineers' Licenses is a part of the Labor Department. This bureau is yet to be organized, its rules formulated, and the work correctly begun. Commissioner Bryant may be depended upon to do this rightly. The engineers of New Jersey have protested against unfair treatment of the commissioner, and we are glad to voice our protest with theirs.

An efficiency commission should seek to promote good work when done efficiently. When its aim is otherwise, it must be made to keep its hands off.

*

The report of the Standard Oil Co., of California, shows an increase in net earnings for 1913 over 1912 of 172.8 per cent., which explains the necessity of increasing the price of oil and gasoline.

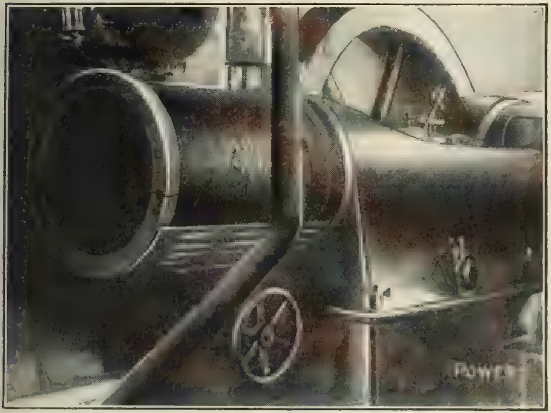
Correspondence

Piston Knocks Out Cylinder Head

A 375-hp. engine, part of the equipment of the Charles City Lighting & Heating Co., Charles City, Iowa, was recently put out of service temporarily by a serious breakdown. The piston, piston rod, cylinder and cylinder head were damaged beyond repair.

At the time of the accident the engine was well loaded. Apparently the piston rod broke flush with the nut holding the piston on the rod, just as the crank was at its outer center.

The head and cover were thrown against the head of a second engine, smashing the cylinder-head cover, but, fortunately, the head was struck near the edge and was not seriously damaged.



Cylinder of Wrecked Engine

The piston rod, except where it broke, the guides, connecting-rod and the crankpin were not sprung or damaged. This indicates that the piston-rod nut broke off just as steam was admitted behind the piston and that the piston was blown off the rod with sufficient force to knock off the cylinder head. There was no indication that any substance had gotten between the piston and the cylinder head.

The piston left the cylinder at an angle and struck a glancing blow against the brick wall of the boiler room. An irregular piece was broken from the edge or corner of the piston. A small crack extended out from the piston-rod hole. It had been known for some time that the piston was cracked at this point and a new piston was to be put in soon. Possibly this crack allowed a slight looseness which caused the rod to break flush with the piston surface.

The cylinder head was not badly damaged. It was evidently blown off squarely, breaking all but four of the studs. The nuts must have split on these four, for the studs were quite straight and the threads but little bruised. The cylinder was cracked about 10 in. longitudinally.

Fortunately, no one was seriously injured. The engineer's hand and arms were cut by glass from a window into which he ran, mistaking it for a door in the darkness.

It is remarkable that there were none seriously injured, as the men were accustomed to pass the end of the damaged engine frequently and often stood near it, because the steam gages and switchboard were easily seen from that position.

C. V. Hull.

Charles City, Iowa.

Steam Gage as Water-Level Indicator

An interesting instance recently came to the writer's notice. There had been a mercury-indicating column in the engine room to show the water level in the tank on the roof, but the glass was broken, all the mercury was lost; and the proprietor refused to buy more. The engine-room force was informed that it would have to go to the roof to see the water level. This soon grew intolrable with five flights of stairs to climb, so an indicator was devised.

An abandoned steam gage was connected to the bottom of the ¼-in. pipe which led to the tank. The fireman was sent above to signal by tapping on the pipe for every foot the water should fall. A cardboard disk had been inserted over the dial face in the gage. Accordingly the engineer marked the various points indicated by the pointer on the disk at the fireman's signals. The gage then indicated the water level.

Edward T. Binns.

Philadelphia, Penn.

Hot Feed Water Caused Pump Trouble

The operation of our boiler-feed pump had not been satisfactory for some time, it having a tendency to race and pound several times a day; sometimes after this occurred it would stick. The conclusion was that this trouble was caused by wear and the outfit was overhauled, but the trouble was still there. As the work had been done by a most reputable machinist, we felt it was not the fault of the pump.

Then it was decided to study local conditions. The pump is in the boiler room and is supplied with water from an open heater, in the engine room, about 100 ft. away. The heater was originally placed near the engine so as to keep the back pressure down. The water level in the heater is about 8 ft. above the pump suction and the 2-in. suction line contains six elbows. We carry 90 lb. boiler pressure and have a back pressure of 10 lb. on the pump. The exhaust pipe goes up from the pump to provide head room and so forms a trap for condensation. A pet-cock was put in this pipe, and was just cracked, but while this helped it did not remedy the trouble.

The feed water ranges from 200 to 212 deg. The piping had recently been changed and the exhaust from one of the engines, which had formerly been wasted, was sent to the heater. The idea was that the 8-ft. drop would force the water to the pump suction and it was wanted as hot as possible. The 100 ft. of pipe and the six elbows are the equivalent of 250 ft of pipe. Pumping 25 gal. of water per min. the loss is 3 ft. per hundred, or a total loss of 7½ ft., leaving but ½ ft. to cause a flow to the heater. Water at 212 deg. temperature can be vaporized by reducing the pressure a fraction of a pound, and without the addition of external heat. This was what was happening.

The gravity head and the pipe friction were almost balanced. The pump made a stroke slightly faster than the average and the suction lift was increased. The water could not flow faster and the extra pull created steam or vapor. The trouble was remedied by removing one of the shelves in the heater, thus keeping down the temperature of the water. This could also have been done by bypassing part of the steam to the atmosphere.

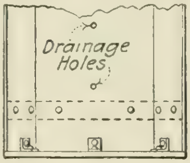
The pump is again operating most satisfactorily, and the lesson has been learned that hot water must flow to the pump and will vaporize if the slightest pull is given over the vaporization point on the temperature-pressure curve.

H. C. Wight.

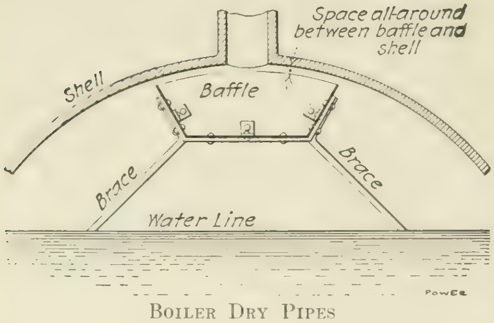
Philadelphia, Penn.

Boiler Dry Pipes

The construction of the dry pipe shown by Mr. Everett in the Dec. 23 issue is different from any that I have seen in that the caps are screwed on water-tight. Usually the end of the pipe is closed by a loosely fitting head which leaves space for drainage.



PLAN OF BAFFLE



Boiler Dry Pipes

Another kind of dry pipe is made of heavy sheet iron with the ends capped, the upper side slotted the entire length, and having several small holes in its lower side for drainage. The current of steam passing through these holes at the bottom would be so small that it would have no tendency to lift the water. When a boiler is priming badly, water will be carried over into the dry pipe, even though there are no holes in the bottom. This water must either be drained out or go over with the steam, defeating the purpose of the device. I doubt very much if the water in the dry pipe would be evaporated. A few small holes in the bottom will at least do no damage. I consider Mr. Everett's pipe a good one, and believe that the drain holes should be left open.

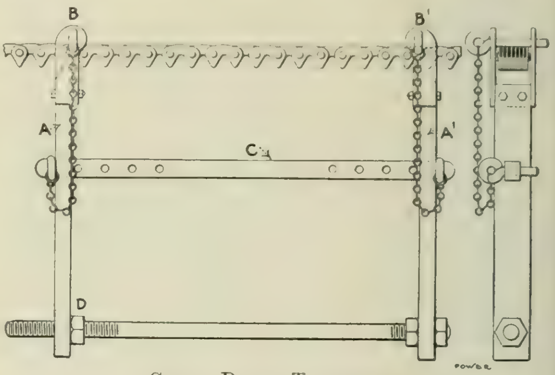
Once I had two boilers, located at the end of the header nearest the engines, which primed badly at times of heavy load, and sometimes the water would fluctuate 8 or 10 in. in the glass. The illustration shows the design of a baffle which largely corrected these conditions.

J. C. Hawkins.

Hyattsville, Md.

Chain-Drive Tightener

A handy tightener is shown in the illustration. The jaws of the bars *A* and *A′* fit between the links of the chain, and are held in place by pins *B* and *B′*. A square rod *C*, with pins in each end, keeps the bars *A* and *A′* from spreading, and several additional holes allow for adjustment. When the nut *D* is screwed out toward the end of the rod, all the slack in the chain is brought between bars *A* and *A′*, so that the required number of links may be removed with ease. The pins on each end of the tightener are attached with chains to keep them from being lost.



Chain-Drive Tightener

Lawrence Kjerulff.

Kansas City, Mo.

How to Buy

One of the essential qualifications of the successful engineer is good judgment in purchasing equipment and supplies. As an example of what not to do, let us assume that the engineer is in need of a steam separator, and after looking at the different makes, he selects one with regard to price and construction.

When he receives the separator, to his surprise there are no companion flanges, bolts, drain valves or glass gage with it. The manufacturers' catalogs show a picture of the separator with all the fittings attached, but nothing is said about the trimmings and the purchaser has assumed that they are included. When the trimmings ust be bought later the "boss" investigates and finds at at least some separators are so furnished, as they ould be, the engineer is criticized, and the buying thereter is closely watched or is taken away from him enrely, and he has fallen a point in the estimation of is employer. Other things, too numerous to mention, uld be used as well to illustrate the same point.

Let us, as engineers, so educate outselves that we can the purchasing ourselves, or be able to give concise formation in our line. Manufacturers are at all times illing to send catalogs and answer questions regarding eir products and it is "up to us," when our employer ks us "Why?" and "How?" to let him know that we are the job and know our business. It may also put a w more dollars into our pay envelope.

Kansas City, Mo. HOWARD G. SCHULER.

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Scientific Management

We are entertained in POWER, from time to time by ntributors, and by editorials, with questions, opinions d even ridicule about the operating engineer.

The editorial, "One-sided Development," in the Aug. issue, asserts that the operating engineer is underid because he has not acquired the business ability eded to sell his services at their real value.

One correspondent goes so far as to feel justified in inking that anyone must be mentally deficient, who orks such long hours for inadequate pay. The point view which inspires this criticism is one-sided or ealistic; it is based on conditions as they should be.

The dictionary's definition of "engineer" is true only eoretically. To the majority of power-plant owners d managers, the engineer is simply the man who keeps e wheels turning around, and it will be some time fore they realize that an engineer may be more than mere starter and stopper—that he may be instrumenl in increasing the profits of the establishment.

If it is necessary to educate the engineer along prossional lines to render him capable of estimating the lue of his services, it is likewise necessary to educate e power-plant owner to safeguard his interest by enging the services of a competent engineer.

The engineer will educate himself readily enough if sees that competence as an economic engineer is at premium, and that his position is jeopardized by lagng behind. On the engineers' part, it is only a queson of demand. When competent engineers are in dend, there will be men who will qualify themselves to pply the need.

In the education of employers and managers a differt element enters. It is hard to believe, but neverthes, there are employers, who are so autocratic toward eir employees, that they will permit even easily prentable losses to continue, rather than ask or accept nomical suggestions, indicating that if there are any anges made they will be the authors thereof. They ll say to him, who has the temerity to offer advice, "ever mind your brains; let's see your muscles."

Employing incompetent engineers is due to ignorance the possibilities of economical management of the am plant. It is only recently that the beneficial relts of scientific management—even in unloading a of pig iron—were made public, and it has created the intended impression on the minds of those who are responsible for the annual dividends.

It is detrimental both to the interest of the engineers and that of the owners, that managers, in many instances, assume, perhaps justly, that an engineer's license is not a certificate of competency; that it is acquired without merit by the holder.

It is easy to advise the engineer to quit his job and go to digging ditches, in order to retain his self-respect, where the management does not treat him deservedly.

Why does the average beginner drift into the boiler room? Because as a fireman, he can make a few more dollars than he would at common labor. He is paid a couple of dollars more, not because the management thinks that the job requires more intelligence, with apologies to the opinion of the minority, but because it is hard work and long hours. He takes the job, because after he becomes familiar with his work, he is practically his own boss. After some years he gets his license, where one is required, or is simply promoted to run the engine, with a little raise in pay. It is only too true that the promotion is usually due, not to possessing the attributes of an engineer of dictionary definition, but because he is willing and obliging, a handy man, etc.

I believe that the majority of these men are progressive, and are perfecting themselves along professional lines; it would be expecting too much for them to go back to the pick and shovel for idealistic reasons only.

In holding down their jobs until there are better places open, they are only following the examples of men of larger importance, who if they were to relate their experiences, would undoubtedly say that they had to be content with an inferior, underpaid job long after they were competent to fill their present positions. There are also many competent, deserving men who never attain the position to which their ability entitles them, notwithstanding the assertion that merit and will power only are necessary to succeed.

New York City. VICTOR BONN

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Standing Charges

In reference to an article of Ralph E. Somers, of New York City, appearing in POWER, Feb. 10 issue, page 204, under the head "Power-Plant Conditions in the South," in the third paragraph he states that the standing charges against a steam plant are 12 per cent.

I would like to ask him how he arrives at this figure, or in other words, for an itemized statement of the factors which make up this figure.

J. McL. JONES.

Charlotte, N. C.

I said that the standing charges "are usually *assumed* at *about* 12 per cent."

Interest	5
Depreciation	5
Taxes and insurance	2
	12

If interest is 6 per cent., depreciation 6⅔, as Reginald P. Bolton wants to charge it on page 180 of the issue of Feb. 3, and if taxes and insurance are a little higher it may be 15, which would make out a worse case for the hydroelectric plant.

New York City. RALPH E. SOMERS.

Engineers' Study Course

Curve Plotting—II

The last lesson showed that any point may be represented by two numbers, called its coördinates, usually written (x, y), or any two numbers may be represented by a point. It is also possible to represent any equation in x and y by a curve or group of curves, but not all curves are capable of being represented by equations, although the simple ones can be. The two unknown quantities (or *variables*, as they are called) in the equation need not be represented by x and y; an equation in u and v or any other letters, would do just as well, but then instead of calling the axes those of x and y, we simply call them those of u and v.

To plot a curve from its equation, we assume various values for one variable, and find what the other variable will equal under those conditions. For example: To plot the equation, $y = 3x + 4$, we make a table as follows:

If $x = -3 \quad y = -9 + 4 = -5$
$x = -2 \quad y = -6 + 4 = -2$
$x = -1 \quad y = -3 + 4 = +1$
$x = 0 \quad y = 0 + 4 = +4$
$x = 1 \quad y = 3 + 4 = +7$
$x = 2 \quad y = 6 + 4 = +10$
$x = 3 \quad y = 9 + 4 = +13$

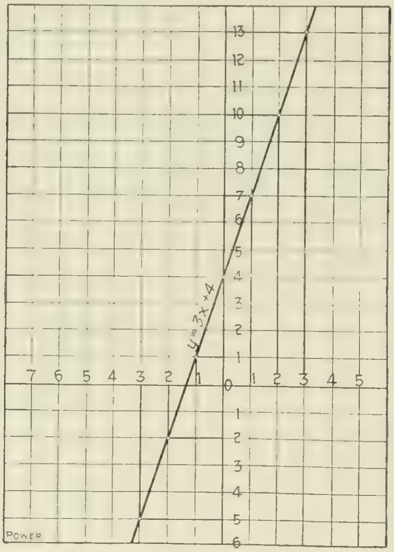

FIG. 3. STRAIGHT LINE

If we now lay off on cross-section paper the points $(-3, -5)$, $(-2, -2)$, $(-1, +1)$, $(0, +1)$, $(1, 7)$, $(2, 10)$ and $(3, 13)$ and connect them we have the curve represented by this equation, in this case a straight line,* Fig. 3. That is, to plot an equation, we assume values for one of our unknown quantities, find the values of the other unknown quantity corresponding to the first, mark off the points corresponding to them and connect them.

There are one or two special cases. The equation $x = 4$, means $x = 4$ for any and all values of y. That is, this is a line parallel to the axis of y, and 5 units fron it. Similarly, $y = 3$, represents a condition that $y =$ for any and all values of x, which is fulfilled by a lin parallel to the axis of x, and three units from it.

However, these are, as said, special cases, and in gen eral any equation of the first degree can be reduced t the form

$$y = mx + b$$

m and b representing any two constant numbers. Thi is the usual form in which the equation of a straight lin is written, and has this convenience, that m, whatever number it is, is the tangent of the angle the line make with the axis of x, and b, whatever number it is, is the distance from the center O, that the line cuts the axis o y. For instance, the equation

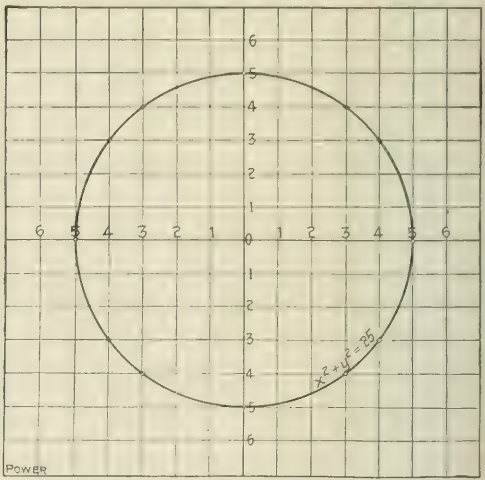

FIG. 4. CIRCLE

$$4y = 3x + 7$$

can be written

$$y = \frac{3x}{4} + \frac{7}{4}$$

and this particular equation could be immediately plotted by taking a distance $\frac{7}{4}$ out on the axis of y, and drawing a line through this point making an angle with the axis of x whose tangent is $\frac{3}{4}$.

Another way in which equations of the first degree can always be written is:

$$\frac{x}{a} + \frac{y}{b} = 1$$

The same equation

$$4y = 3x + 7$$

reduces to

$$\frac{y}{\frac{7}{4}} - \frac{x}{\frac{7}{3}} = 1$$

or in the above formula $a = -\frac{7}{3}$, $b = \frac{7}{4}$.

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*Every equation in which x and y are found only in the first power represents a straight line.

In this form of writing the equation, a and b are the distances from the center on the axes of x and y, where the straight line cuts these axes. These distances are known as the *intercepts* on the axes of x and y.

Knowing this much about the straight line, we can find the equation where we have the line. Suppose a straight line passes through the points (4, 2) and (—5, 3). Let us find the equation in the form

$$y = mx + b$$

When $x = 4$, $y = 2$; when $x = -5$, $y = 3$ therefore,

$$2 = 4\,m + b \qquad (1)$$

$$3 = -5\,m + b \qquad (2)$$

Subtract (2) from (1) $-1 = 9\,m$, or $m = -{}^1/_9$; Substituting in (2)

$$3 = \tfrac{5}{9} + b, \text{ or } b = \tfrac{22}{9}$$

Then the equation of a line passing through points (4, 2) and (—5, 3) will be

$$y = -\tfrac{1}{9}\,x + \tfrac{22}{9}, \text{ or } 9\,y = -x + 22$$

The matter becomes a little more complicated when the equation is quadratic, i.e., contains squares of x and y. Suppose $x^2 + y^2 = 25$, then

If $x = 0$, $y = \sqrt{25} = 5$
$x = 1$, $y = \sqrt{24} = 4.9$
$x = 2$, $y = \sqrt{21} = 4.6$
$x = 3$, $y = \sqrt{16} = 4$
$x = 4$, $y = \sqrt{9} = 3$

$x = 5$, $y = \sqrt{0} = 0$
$x = -1$, $y = 4.9$
$x = -2$, $y = 4.6$
$x = -3$, $y = 4$
$x = -4$, $y = 3$
$x = -5$, $y = 0$

If we plot the points corresponding to these values, and connect the points, we find we have a circle, as in Fig. 4. In general, any equation of the form $x^2 + y^2 = r^2$ is a circle of radius r. (In the above example the radius is $\sqrt{25} = 5$.

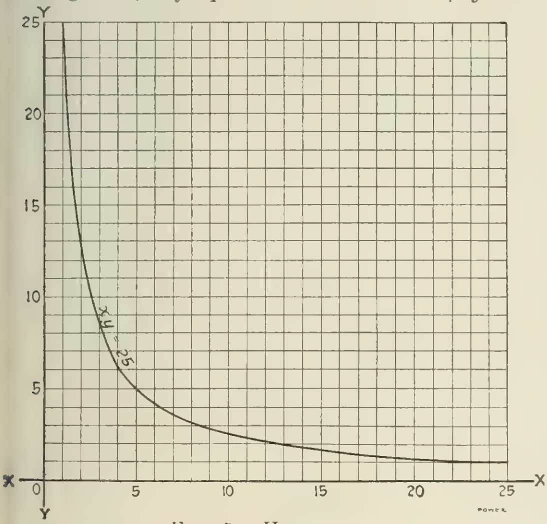

FIG. 5. HYPERBOLA

If we take the curve $pv = 25$, then when

$p = 10$ $v = 2.5$;
$p = 9$ $v = 2.78$;
$p = 8$ $v = 3.13$;
$p = 7$ $v = 3.57$;
$p = 6$ $v = 4.17$;

$p = 5$ $v = 5$
$p = 4$ $v = 6.25$
$p = 3$ $v = 8.33$
$p = 2$ $v = 12.50$
$p = 1$ $v = 25$

If we plot this curve, measuring the *"p's"* on the axis of y, and the *"v's"* on the axis of x, we obtain a curve which represents the behavior of steam as it expands, or air as it is compressed, without change of temperature. (The engineer will immediately recognize this as a part of his indicator diagram.) It is a part of a curve known as an *equilateral hyperbola,* and the rest of the curve may be obtained by plotting:

$p = -10$ $v = -2.5$
$p = -9$ $v = -2.78$ etc.

(The minus branch has no physical meaning.)

Fig. 5 is an hyperbola, a plot of an equation of the form $xy = 25$.

In like manner we may plot any equation, by making a table of values of y corresponding to various assumed values of x, finding the points corresponding to each pair of values, and passing a straight or curved line through these points.

We can summarize much information concerning the simpler equations. Every equation of the first degree is a straight line. Every equation of the second degree is either a circle, an ellipse, a parabola, a hyperbola, or a pair of straight lines.

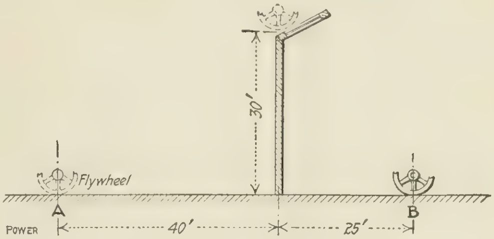

FIG. 6. PROBLEM OF BURST FLYWHEEL

Any equation of the form $y = mx + b$ represents a straight line in which m is the tangent of the angle between the line and the axis of x, and b the intercept on the axis of y.

$$\frac{x}{a} + \frac{y}{b} = 1$$

is a straight line where a and b are the intercepts on the axis of x and y respectively.

$$x^2 + y^2 = r^2$$

is a circle, whose center is the point O, O, and of radius r.

$$(x - a)^2 + (y - b)^2 = r^2$$

is a circle, whose center is the point a, b, and of the radius r. (The simpler equation may be derived from this by putting $a = o$, $b = o$)

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

is an ellipse, with O, O as the center, and a and b as semi-diameters.

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

is a hyperbola, with the axes of x and y as its axes.

$xy = a$ is an equilateral hyperbola, with its axes at 45 deg. to $X'\,OX$ and $Y'\,OY$.

$y^2 = kx$ is a parabola, whose axis is $X'\,OX$.

Now, what is the good of all this? Can any problems be solved by it which are not easily solved otherwise? Here is an elementary one which is more easily solved by plotting equations than in any other way.

Suppose, as was an actual case, a flywheel burst at B, Fig. 6, a piece just cleared the wall 25 ft. away, 30 ft. high (it actually went through a skylight) and alighted 40 ft. farther off. How high did it go?

Bodies thrown into the air travel in parabolas, and the highest point is midway from A to B. We draw our figure then, as in Fig. 7.

The parabola is of the form $x^2 = -ky$. By the conditions of the problem, the parabola goes through point B (32.5, $-y$) and through C (7.5, $-y + 30$). (Try to see how these coordinates are obtained). Then

$$32.5^2 = -ky \qquad (1)$$
$$7.5^2 = k(y - 30) \qquad (2)$$

Solving by dividing (2) by (1)

$$\frac{7.5^2}{32.5^2} = 1 - \frac{30}{y}$$

which gives

$$y = \tfrac{507}{16}, \text{ or } -y = -\tfrac{507}{16}$$

That is: the wheel at its highest point was $31\frac{11}{16}$ ft. off the ground.

Other applications are. If two simultaneous equations are given, as

$$x + 3y = 16$$
$$x^2 + y^2 = 36$$

an approximate idea of the solution may be had by plotting these equations. The intersections of their graphs are the solutions of the simultaneous equations.

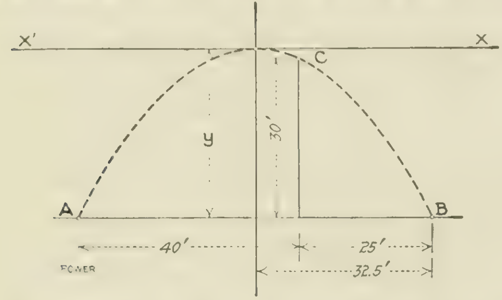

FIG. 7. PLOT OF THE PATH TAKEN BY FLYWHEEL PIECE (PARABOLA)

Or, in the equation

$$x^3 - 2x^2 + 3x - 4 = 0,$$

if we put

$$y = x^3 - 2x^2 + 3x - 4,$$

and plot the graph, we can get an idea of the approximate roots of the equation, as these will be where the graph crosses the x axis.

If $x = -5$, $y = 194$
$x = -4$ $y = 112$
$x = -3$ $y = -58$
$x = -2$ $y = 26$
$x = -1$ $y = -10$
$x = 0$ $y = -4$
$x = 1$ $y = -2$
$x = 2$ $y = +2$
$x = 3$ $y = +14$

There is a root between +1 and +2, and by computing between these points we can approximate it as closely as we please.

⁂

Miners' and Mechanics' Institutes—At a recent meeting of the board of trustees of the University of Illinois, R. Y. Williams was appointed director of the Miners' and Mechanics' Institutes, which are to be established under the direction of the department of mining and engineering. Authority for the establishment of these institutes was granted by an act of the state legislature in 1911, but no appropriation was made to carry out the authorization until the latter part of the recent session of the legislature, at which time an appropriation of $15,000 per annum was made. The purpose of the Miners' and Mechanics' Institutes is somewhat similar to that of the Farmers' Institutes, but their specific purpose is to assist men who are preparing themselves to pass the tests required by the state before they can hold official positions about the mines.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

That we should babble about the income tax! Think of all the worry (and the collectors) we escape, the dignity we don't have to support, the jealousy and sneers we don't excite. Great, ain't it, not to be forced to accept a three or a four thousand dollar salary? Just plain "wages" for you and me, Ignatz. And yet there are times.

⁂

This from the "Scientific American," which is as versatile as it is scientific: "It has been advanced by persons in a position to know that the styles in ladies' corsets exert a marked influence upon the design of automobile upholstery. One style of corset, in vogue today, may encourage a luxurious lolling position of the wearer, another style, in vogue tomorrow, may compel a severely upright position. Consequently designers find it incumbent to study other things besides automobile engineering."

Keep this item to yourself. If your wife sees it, she'll get dissatisfied with her present car.

⁂

"You can never eliminate the human element," declares the president of Yale. All the more credit, then, for the Pennsylvania System, which states that "not a single passenger out of the 111,000,000 carried in 1913 was killed in a train accident."

⁂

The following trickles into the Spillway from "Constant Reader," and we reprint it as a mark of esteem for the engineering knowledge of the young lady who thus describes the building of a locomotive:

"You pour a lot of sand into a lot of boxes, and you throw old stove-lids and things into a furnace, and then you empty the molten stream into a hole in the sand, and everybody yells and swears. Then you pour it out, and let it cool, and pound it, and then you put it in a thing that bores holes in it. Then you screw it together and paint it, and put steam in it, and it goes splendidly, and they take it to a drafting room and make a blueprint of it.

"But one thing I forgot—they have to make a boiler. One man gets inside and one gets outside, and they pound frightfully; and then they tie it to the other thing, and you ought to see it go!"

⁂

An American engineer in Cuba tells the following:

"One time, while trying to start a refractory gas engine whose igniter was out of order, I managed to fire an accumulation of gas in the muffler pot with the result that would shame a 12-in. gun. The panic among the factory hands was more than funny. They did not wait to use the doors but went out through windows and every crevice that would allow a man to pass, and then kept on going for some time. The mechanic in charge proved to be the best sprinter, as he did not stop until he reached home. Later he sent a man around to get his coat and dinner-pail, with a message that he was a mechanic, not a gunner."

⁂

Our friend Charley Johnson, out Minneapolis way, sends us this clipping:

"A. C. Rutzen declared he has perfected a spring motor that will transmit power in abundant quantities; Rutzen says his invention comprises sixteen high-powered springs, fifteen of which give forth power while one is perpetually being rewound. The model is high and twenty-two inches wide. Twenty electric lights from power generated have been giving forth a steady glow for nearly a year."

⁂

And Charley suggests that we "notify the engine builders to stop manufacturing before it becomes necessary to appoint a receiver; any one can see at a glance that the steam engine will be a thing of the past. The power plant of the future will consist of 'sixteen springs' 'neatly packed in a hardwood case ready for use', sent anywhere in the United States upon receipt of price. I don't believe it is advisable to exploit this too heavily, as some of the fraternity who have not as yet been run on an open throttle might try to make an engine and only use 15 springs, and the consequent short-circuit might be more than their crankshaft can stand."

Power Plant Changes Save Coal*

By Warren O. Rogers

YNOPSIS—An engineer upon taking charge of a steam ant found a miscellaneous collection of engines and aps, and old-time methods in vogue. All but one of 14 aps were dispensed with, and five steam engines and ve of nine steam pumps were discarded. A 100-kw. genrator was belted to the main engine to carry the electrical ad, by using a simple drive system, although several conulting engineers said it could not be done.

*

When the new engineer assumed charge of the steam lant of the Blank Manufacturing Co. he found that two 2-in. by 18-ft. and one 78-in. by 20-ft. return-tubular oilers were required to supply steam to six engines of rious horsepower and design. Two of those engines were irectly connected to direct-current generators. Nine umps, of miscellaneous types, were also doing their share consuming steam. As his eyes traversed the boundaries the engine room he discovered 14 steam traps for handng the return from various heating coils and machinery ed in the mill.

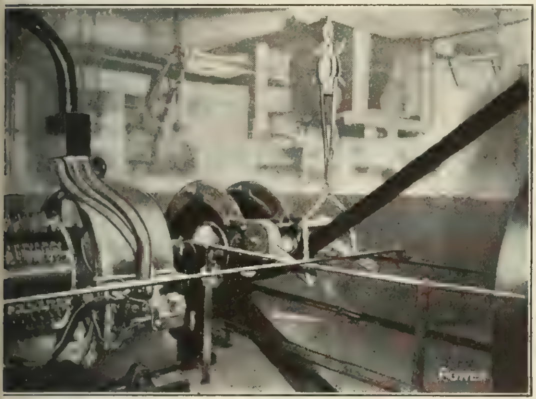

Fig. 1. Application of the Lenix Drive

After familiarizing himself with his plant and the work the mill the engineer returned to his office to think. e concluded that if matters were allowed to continue, e plant would be a good proposition for the central ation, at almost any charge for electrical energy, and ill be an inducement for the owners to change from their vn power to central-station service.

Engineer "Wise" did more than think; he put on his eralls and jumper and went to work. It was a puzzle st where to begin, but a start was made in the boiler om, where a forced-draft fan blower was driven by a -year-old 8x10-in. vertical engine. The engine-driven nerators were underloaded and a motor-driven fan apaled to Engineer "Wise." To be on the safe side the akers of the fan were consulted regarding the size of e motor necessary to drive the fan. Sixty horsepower as recommended and "Wise" felt faint. After duly nsidering the matter a 15-hp. motor was placed on a elf in the boiler room and belted to the pulley of the 36-in. diameter, 22-in. face, blower. The motor drives it at 600 r.p.m., and produces ample air pressure for the boiler furnace.

The traps and piping system, which appeared complicated and, in most instances, unnecessary, were studied. The returns from the factory came back to traps which discharged into a receiving tank, from which the water was pumped through the heater to the boilers. The discharge of water and steam into the receiving tank was responsible for nearly as much steam escaping to the atmosphere, through a 3-in. vent pipe, as came from the engine exhaust, after heating the feed water. To prevent the escape of steam from the vent pipe it was the practice to admit cold water to the receiving tank, and all excess water not used for boiler feed ran to the sewer through the overflow pipe; a useless waste in both cases.

"What is the use of those traps," thought Engineer "Wise," and out they came. The high-pressure returns from presses, heating table and other sources were connected to one pipe, which discharged into the blowoff pipe of each boiler. But one trap was retained, which handles the low-pressure drips. This saved the steam and water that had been allowed to go to waste from the receiving tank, also the steam used to operate the traps.

At one side of the factory there was a reservoir for storing water used about the works. The water was pumped from a well to the reservoir, and from the reservoir to a tank on the roof and to a water-softening system. From the water softener the water ran to the return tank by gravity. The water softener was discarded as useless, and water from the well is now pumped to the return tank for the makeup water as required, also to the factory water piping, the pump being automatically controlled.

Out in the factory a 20x48-in. Corliss engine drove two sets of rolls, and was greatly underloaded. Engineer "Wise" conceived the idea of driving a 100-kw., 125-volt generator from this engine and shut down the two engine-driven generators in the other engine room. The Corliss engine had a 14-ft. flywheel with a 13-in. rim face. The engine room was restricted in floor space, and placing the generator with a 22-in. pulley, in line with the engine flywheel, would give about 14-ft. centers, which, with the ordinary drive, would not be practical.

Several consulting engineers were called on to solve the problem. One advised putting the generator out in the yard and housing it in, using a long belt drive. Another advised setting up a countershaft out in the yard and belt from the engine to it and from the countershaft back to the generator, placed alongside of the engine cylinder.

Engineer "Wise" was not satisfied with any of the propositions submitted and insisted on some kind of a drive that would allow placing the generator in the engine room. The general verdict was, however, "It can't be done."

"That does not go here," said "Wise," and started on a hunt for an engineer who could install a drive that would permit of placing the generator in the engine room at the crank end of the engine. In his search for help he took the matter up with F. L. Smidth & Co., of New

---

*The changes were made in a Brooklyn plant, and the cidents recorded herewith actually occurred.

York, who solved the difficulty by installing a Lenix drive, as illustrated in Figs. 1 and 2. This drive consists of a cast-iron base on which a semicircular arm is pivoted at one end. At the other end is an idler pulley and shaft which runs in bronze bearings. At the pulley end of the idler arm two weight-arm extensions and weights are provided for adjusting the tension of the belt. This arrangement gave a distance between the engine and generator-shaft center of 14 ft., with a pulley ratio of 1 to 7.6. The belt is double and 12 in. wide.

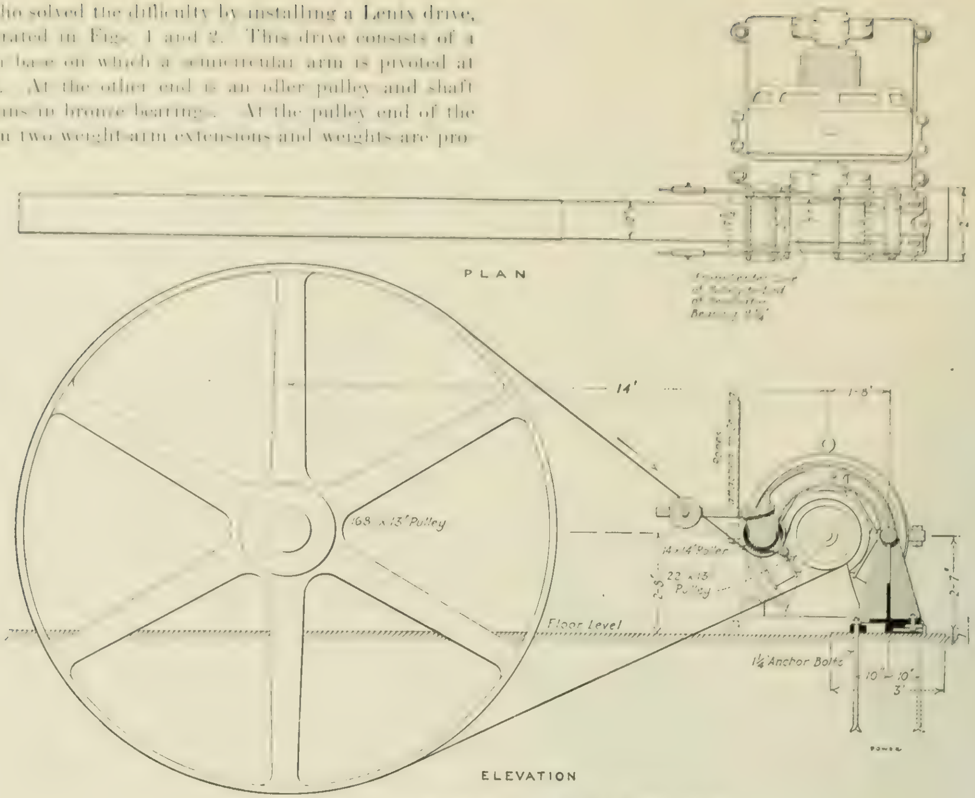

FIG. 2. DETAILS OF THE DRIVE AS INSTALLED

With this arrangement of drive the Corliss engine now carries the factory load and the two direct-connected engines have been shut down. Besides this two vertical engines used for driving cylinder rolls have been displaced by two 40-hp. direct-current motors. This change resulted in a more uniform speed and an increased and better quality of product.

All of these combined changes necessarily affected the coal consumption. Before they were made the three boilers were used, burning soft coal at a cost of $4.15 per ton of 2240 lb. During the first week of Feb., 1910, 101,108 lb. or 45.1 long tons were burned at a cost of $187.16. Under Engineer "Wise" management, since the changes, a mixture of anthracite dust costing 25c. per ton is used in proportion of two parts of anthracite dust to one part of soft coal, the latter costing $3.95 per ton, the average mixture being $1.48 per ton.

For the first week of Feb., 1914, 26,464 lb. of soft coal at $3.95 per ton of 2240 lb. and 42,921 lb. of anthracite dust at $0.25 per ton of 2000 lb. were burned. This equals 11.8 tons of soft and 21.4 tons of dust at a total cost of $46.61 and $5.35, respectively. This makes a total coal consumption of 33.2 tons, at a cost of $51.96, or an average cost of $1.57 per ton. The difference in coal consumption for the first two weeks of the two years cited, is 45.1 — 33.2 = 11.9 tons. The difference in the cost of coal for the same periods is 187.16 — 51.96 = $135.20 or a 36 per cent. saving.

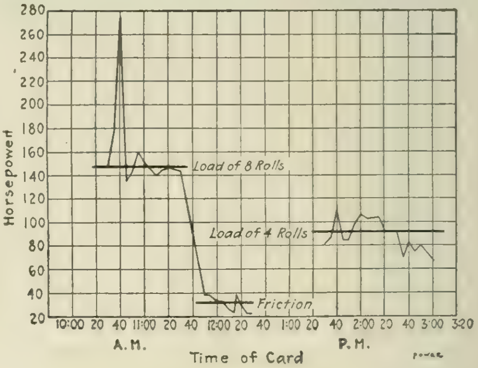

FIG. 3. ROLL LOAD

Before the change the motor load was 250 amp., now it averages 650 amp., several additional motors having been installed in the mill.

In Fig. 3 is shown a load curve of the friction load, normal load with four and eight rolls on the engine and a peak which occurs if material is fed to the mill rolls simultaneously.

The preceding is an instance of what a wide-awake engineer can do to better plant conditions and also shows that the decision of a consulting engineer is not always the last word in power-plant practice.

Powdered Coal as a Fuel--a Review*

By Joseph Harrington

SYNOPSIS—Tells what degrees of fineness have been found best for the combustion of powdered coal. Some cost data relative to pulverizing and burning are given.

* * *

A proper intimacy of mixture of air and fuel when burning powdered coal requires that the powdered substance shall have the nature of a cloud of dust, completely and uniformly diffused, remaining suspended in the air current until burned. When in this condition every minute particle is inclosed or surrounded by a quantity of air, which is substantially that required for its complete combustion. Given a temperature sufficient for rapid ignition, a state almost ideal for perfect combustion is obtained.

Authorities are practically agreed as to the standard of fineness required for right conditions. While pulverization can perhaps be overdone, there is much more likelihood of the fuel being too coarse. A piece of coal larger than will pass through an 80-mesh screen will not burn completely in the time allowed, but will be deposited somewhere in the furnace, or pass out of the stack partly consumed.

H. R. Barnhurst states the requirements for best results as follows:

1. Coal must be dried to contain not over 1 per cent. of moisture.
2. It must be pulverized to a high degree of fineness.
3. It must be projected into a chamber hot enough to cause instant ignition.
4. It must be supplied with sufficient air for complete combustion.

Enlarging on the second requirement, he gives as a standard of fineness these figures: 90 per cent. through a 400-mesh screen; 2½ per cent. to 5 per cent. through a 200-mesh screen; the balance through a 100-mesh screen. A somewhat coarser grind is stated by A. W. Raymond as sufficient. His standard is 98.5 per cent. through a 100-mesh screen, or 91 per cent. through a 200-mesh screen for best results.

In comparing any figures of this nature it must be kept in mind that there is present in powdered fuel a certain percentage of extremely fine material, depending upon the character of the coal structure, moisture content and method of pulverization. Calibration by means of sieves establishes only the maximum size, and ignores completely the other limit. Unquestionably, however, the character of the flame is influenced materially by that uncertain quantity of impalpable dust, which gasifies instantaneously and leads the procession of combustion events.

Dry coal can be ground with about 85 per cent. of the power required for moist coal, and a condition of not over 1 per cent. moisture is required, if the fuel is to be stored or conveyed. The slightest dampness causes a balling up, and a 3 per cent. moisture content results in an actually pasty condition. James Lord states that coal should not have over 1 per cent. of moisture.

Probably the point of greatest divergence of opinion is the amount of combustible volatile the coal should contain to be suitable for burning as powdered fuel. The majority of writers seem to think that 30 per cent. of volatile matter is a prerequisite, but some report satisfactory conditions with but 20 per cent. It is evident that the higher the volatile the larger is the amount of combustible converted into gas by the mere application of heat, leaving a smaller portion of fixed carbon to burn during its flight through the furnace. Just where the limit is reached has not yet been disclosed by authentic tests.

There are two methods of firing that can briefly be described.

The process required where considerable quantities of coal are to be prepared, consists in crushing the coarser lumps so they will pass through a 1¼-in. screen in preparation for the dryer. The finer the coal coming to the plant the easier it is to both dry and mill it.

The dryer most favored is the rotary kiln discharging the dry coal to a conveyor, which carries it to the pulverizer, where it remains until fine enough to be carried away by a current of air or pass through screens of the specified fineness. It is deposited in a hopper from which it can be conveyed to any desired place. It is stored in covered bins and handled by means of screw conveyors turning in closed troughs. Not only is loss thus prevented, but the air present is not sufficient to permit of explosive mixtures. No accident of explosive nature has ever occurred to coal handled or stored in this manner.

At the point of consumption a small bunker is provided, like an inverted pyramid, having a small screw conveyor at the apex. This extracts the powdered coal as required and lets it fall into the blast pipe, where it is instantly dispersed and carried to the furnace with the air for combustion.

The second method is advocated by some, wherein the same fan used to extract the dust from the mill is also used to blow the mixture into the furnace. Again, a considerable difference of opinion exists as to the practicability of this method, owing to the amount of air considered necessary for transportation as compared to that required for combustion of the fuel.

Data relative to the cost of fuel preparation becomes of primary importance, since the entire subject is relegated to the domain of academic inquiry if economy is not obtained. The cost of the pulverization must be added to the delivered cost of the coal, which must include the usual items of total cost, such as interest, maintenance, depreciation, labor, etc. All of these figures are not available to the writer, but some analysis is possible.

Mr. Lord presented these figures to the Engineers' Society of Western Pennsylvania at Pittsburgh:

	Rate per Gross Ton of Coal Produced
Fuel	$0.034
Repairs to buildings	0.002
Operating	0.145
Power (steam and electric)	0.221
Repairs to machinery and equipment	0.200
Total	$0.602

"This total includes the cost of automatic transmission through pipes to the furnaces.

"Analyzing the last expense item, we find repairs which should be charged over the past eight years, so that the total cost of preparation and transmission did not properly exceed 50c. per ton of pulverized coal produced during 1912.

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*"Power," Jan. 13, p. 69; Feb. 17, p. 254.

"If you dissociate the transmission from the actual preparation, the cost of the latter would be less than 10c. Many plants would not require the extensive transmission required by us. When the coal is prepared as herein outlined, smoke is practically eliminated."

If these costs are reduced to a basis of the short ton, we have these figures:

	Long Ton	Short Ton
Total cost	$0.602	$0.547
Same corrected	0.50	0.455
Preparation only	0.40	0.364

A. W. Raymond, in *Cement Engineering News*, give the average cost per ton of coal ground of 14 pulverizer grinding 99.5 per cent. to 100 mesh as $0.325. Thi on a basis of power at $1\frac{1}{2}$c. per kw. hr.

The ash content does not affect the possibility of properly milling a coal and the lower grades of fuel can b successfully burned. A higher combustion efficiency offsetting the decreased heat value of the coal, some color i given to the claims of overall economy. Combustion experts are at work and results of interest and value ma develop.

[Another article on this subject will soon appear—Ed.

* *

Transportation Problems of the Power Station

By T. H. Reardon

Having been identified with transportation interests, and acquainted with the hardships that beset steam-generating stations, it is from personal knowledge upon which the statement is made that transportation companies often have wanton disregard for the interests of the best class of patrons that a railroad company is called upon to serve.

Coal, from the railroad company's point of view, is "dead" freight—that is, it will sidetrack and stay anywhere until it is convenient to move it. If a power station is down flat for want of fuel, it can shift for itself, beg, buy or borrow. Following a period of congestion on transportation lines when things do loosen up, delayed traffic moves like an avalanche; there are not enough side tracks at any station to accommodate the influx and the power-station man may have 50 cars of coal on his hands at once.

Then he is notified that so many cars of coal are awaiting his further pleasure. This means that the cars would be actually trestled for unloading if the consignee was in a position to take them. The cars, therefore, go on demurrage and, after a lapse, usually of 48 hr., each car is earning $1 a day or fraction thereof it is delayed in unloading.

Of course, there is a redress if the proper course is pursued and if the consignee is familiar with red tape and transportation rulings as filed with the Interstate Commerce Commission.

As to charges for delay to cars during the unloading process, the consignee has two options: One is the regular charge, and makes allowance for inclement weather during the time of unloading, for bunching or congestion in transit and for various other matters that interfere with regularity in movement and in unloading. The other is the average agreement plan, according to which each car placed for unloading and emptied within 24 hr. earns a credit, while each car delayed over 48 hr. earns a debit. These credits and debits are balanced at the end of the month. If there is an excess of debits, the patron pays the transportation company at the rate of $1 per debit. If there is an excess of credits, however, the patron does not receive any refund. In this connection there is no allowance for inclement weather nor for congestion in transit with cars arriving badly bunched.

Then there is the local switching service at destination, the character of which will depend largely o whether the power station has service from two railroad or only one. This is an evil connected with station location and if not eliminated at the beginning it must b tolerated.

There are many other transportation problems connected with station operation, and all such should, s far as possible, be handled to best subserve the interest of the power station.

Essential to the welfare of the power station and it manifold interests is a thorough knowledge of all transportation problems. The practical way to secure thi particular talent is to invade the railroad freight offic and hire the most competent clerks that railroad service can furnish. Such a man would be familiar wit rates, routes and classifications, special rulings, etc.

Minimum loads (a car taking a carload rate) ar billed at a certain weight whether the car contains suc an amount or not. Specific routing should always b furnished in giving shipping instructions to transportation companies, and a bill of lading should be take showing this routing and the rate, prepayment clas weight and all other essential points. By neglecting the simple precautions, a shipment will often travel a lon and circuitous route to further the interests of th initial carrier at an expense and inconvenience to th consignee, who can rarely obtain redress.

All bills for freight, demurrage, switching charge etc., should be audited by men thoroughly familiar wit this work. An accurate record should be kept of th time all cars are placed for either loading or unloading and when cars remain on hand for several days, the dail record should show the car initial, number, location, an fraction of load contained, or empty, as the case ma be. No freight should be acknowledged on a receip without positively knowing that it has been received, an if in bad order its condition should be noted.

Practically all live concerns employ trained railroa clerks to protect their transportation interests. Thi practice cannot be commended too highly. Such men a a rule can do any class of work that comes up in the offic and the man alive to his own interests will do well if h will make a selection from a railroad freight office instead of hiring school graduates.

Friction of Lineshaft Bearings

SYNOPSIS—Results of an extended series of tests to determine the friction of babbitt, roller and ball bearings under different speeds, loads and temperatures.

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In a paper read before the American Society of Mechanical Engineers, by Carl C. Thomas, E. R. Maurer and L. E. A. Kelso, some interesting data were given on the absolute and relative power required to drive a specially constructed series of shafts, flexibly connected and carrying loads uniformly distributed, when the shafts were supported successively by 20 ring-oiled babbitt bearings, then by 20 roller bearings, and finally by 20 ball bearings. Wide ranges of loads and speeds were covered and the coefficients of friction were worked out for each type of bearing.

The apparatus, which was designed and built in the department of steam and gas engineering at the University of Wisconsin, consisted of 25 ft. 10 in. of lineshafting in five equal sections, mounted in hangers which were inverted and used as floor stands. The hangers were bolted to two 8-in. I-beams which were leveled on the floor, and the shafts were of cold-rolled steel, $2\frac{7}{16}$ in. in diameter. Each section was 5 ft. 2 in. long; the adjacent sections were coupled together by means of a flexible leather disk or two straps connecting the two flange couplings. The flexible couplings prevented transmitting any part of the load applied on one shaft to either adjoining section and binding between shafts and bearings due to possible lack of alignment. A direct-current Fort Wayne motor was directly connected to one end of the shafting by means of a flexible coupling.

The three kinds of bearings tested were the Hess-Bright ball bearing, the ring-oiled babbitt bearing made by the Dodge Manufacturing Co. and the Hyatt roller bearing. All bearings were for the same size of shaft, and the same pieces of shafting were used for all the tests. The babbitt bearing was $9\frac{3}{32}$ in. long and its projected area 22.36 sq.in. Each roller bearing contained six right-hand and six left-hand rollers 0.78 in. in diameter; six were $9\frac{9}{16}$ in. and six were $9\frac{3}{16}$ in. long. The bearings were of the type in which a cage is used for holding one-half the rollers. Each ball bearing contained a single set of balls $\frac{9}{16}$ in. in diameter. The diameter of the inner race through the ball groove was 3.4729 in.

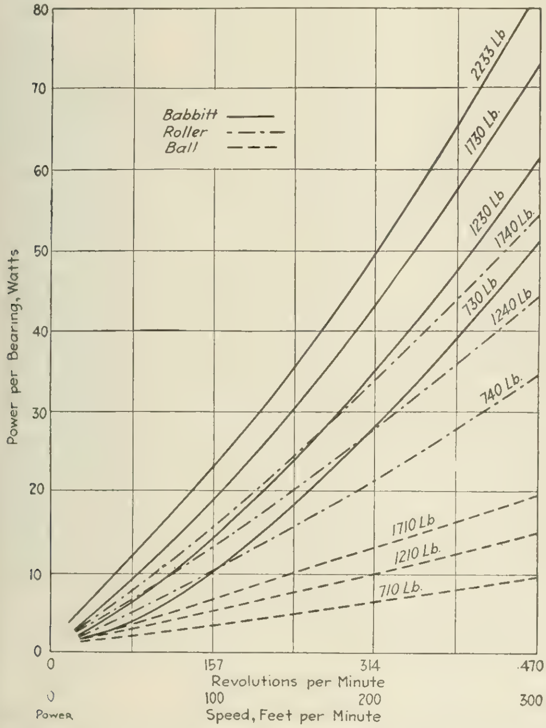

FIG. 1. POWER CONSUMED BY FRICTION; BEARINGS AT 100 DEG. F.

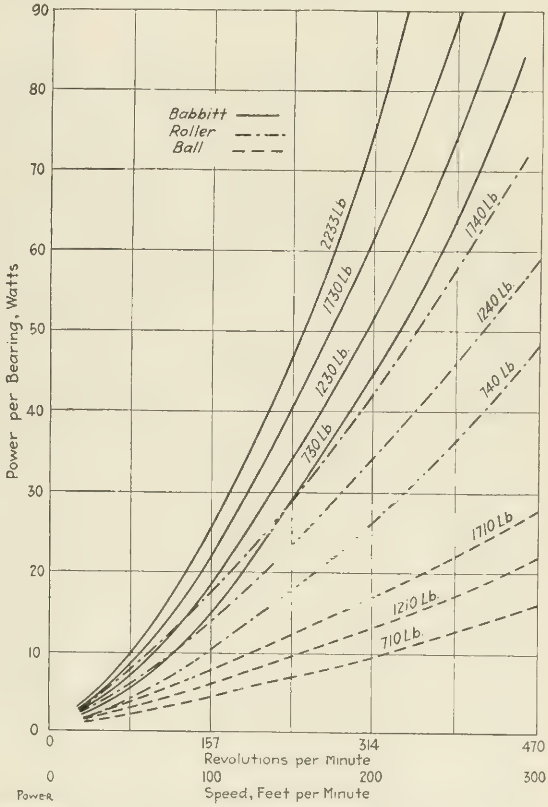

FIG. 2. POWER CONSUMED BY FRICTION; BEARINGS AT 77 DEG. F.

In the tests the speeds were between 150 and 450 r.p.m., corresponding respectively to about 100 and 300 ft. per min. peripheral speed. Most of the loads were between 700 and 1800 lb. per bearing, corresponding to about 30 and 80 lb. per sq.in. for the babbitt bearing.

Figs. 1 and 2 show a comparison of the babbitt, roller and ball bearings for 100 deg. and 77 deg. respectively. Each curve gives the power required per bearing to run the shaft under the load and speed indicated. Both figures show that the power for the babbitt is higher than for the other bearings except perhaps at low loads and speed, and that the power for rollers is higher than that for balls. The excess of power for babbitt over rollers and rollers over balls increases with the increase of speed for all loads. The accompanying table shows the relative amounts of power consumed in friction by the three kinds of bearing at the speeds and temperatures indicated.

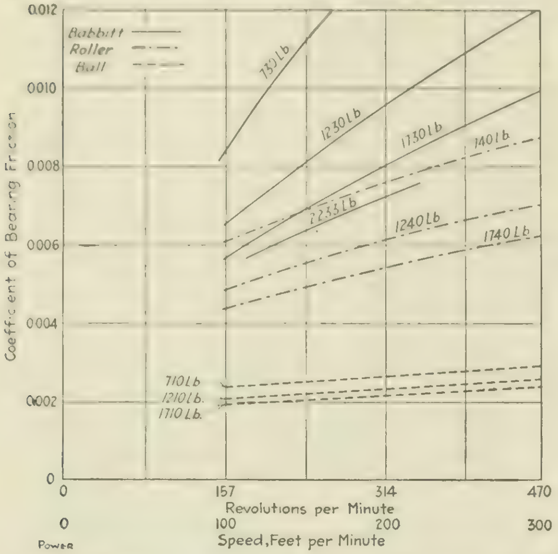

FIG. 3. COEFFICIENTS OF FRICTION; BEARINGS AT 77 DEG. F.

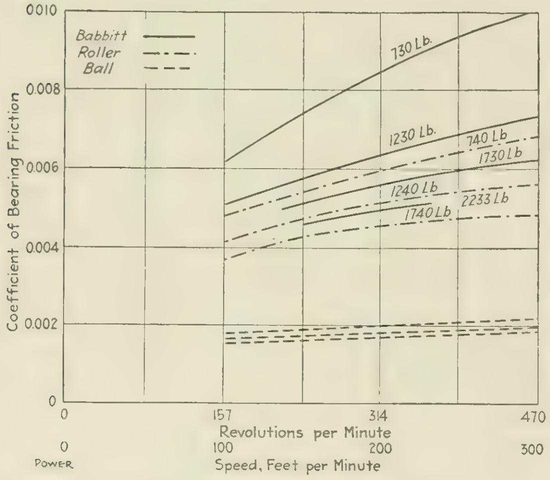

FIG. 4. COEFFICIENTS OF FRICTION; BEARINGS AT 100 DEG. F.

The relative numbers are based in each case on the average power for three loads: 710, 1210 and 1710 lb. for balls; 740, 1240 and 1740 for rollers, and 730, 1230 and 1730 for babbitt.

Figs. 3 and 4 present the comparison in another way; the ordinates are coefficients of friction instead of power as in the two preceding figures.

RELATIVE AMOUNTS OF POWER CONSUMED IN FRICTION

Bearings	100 Ft. per Min. 77 deg.	100 Ft. per Min. 100 deg.	300 Ft. per Min. 77 deg.	300 Ft. per Min. 100 deg.
Ball....	1	1	1	1
Roller....	2.2	2.5	2.7	3
Babbitt....	3	3.6	4.5	4

A series of curves were presented to show how the coefficients for babbitt, roller and ball bearings change with the time after starting. In each case the coefficient, and hence the power, decreased rapidly at first. For the babbitt bearing there is a marked difference between the average coefficient for the first and for the second hour; this difference is less marked with the roller bearing and still less with the ball bearing.

Fig. 5 shows the rise in temperature for the different kinds of bearing under practically identical conditions. Curve *A* is for babbitt bearings under a load of 1230 lb. per bearing, curve *B* is for roller bearings under 1240 lb., curve *C* for roller bearings under 1740 lb. and curve *D* for ball bearings under 1710 lb. In the tests represented by curves *A* and *B*, the speed was 350 r.p.m., and the room temperature 80 to 81 deg.; in those resulting in curves *C* and *D* the speed was 450 r.p.m. and the room temperature 78 to 80 deg.

Breakdown tests were run on each type of bearing with only one section of shafting on which were four bearings. The maximum load was about 5000 lb. per bearing. A speed of 200 r.p.m. was chosen because it represents about the average lineshaft speed in practice. The tests began at about 3200 lb. per bearing. Failure occurred at about 4250 lb. per bearing in the case of the babbitt, 4650 lb. of the ball bearing and about 5100 lb. of the roller bearing. The bearings did not fail structurally as the power was cut off soon after distress was manifested, but the failure was simply that of the lubricant. The authors also told how the methods of testing were developed and in an appendix gave diagrams of motor losses and graphical logs of tests.

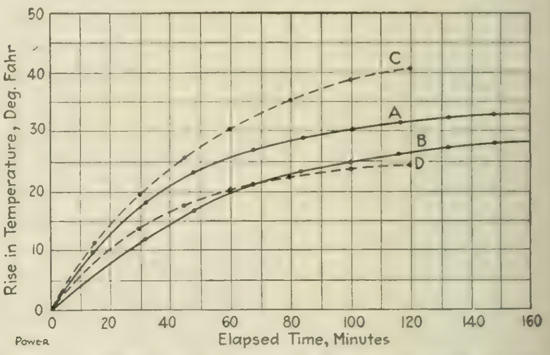

FIG. 5. RISE IN TEMPERATURE WITH BEARINGS UNDER PRACTICALLY IDENTICAL CONDITIONS

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Turbine Blade Vibration—An interesting statement is made that the low-pressure blades of one of the first large turbines built failed apparently because the natural period of vibration coincided with the half period of revolution and resonance ensued. This was stopped permanently by soft soldering an additional lacing wire to the blades at half height.

⁂

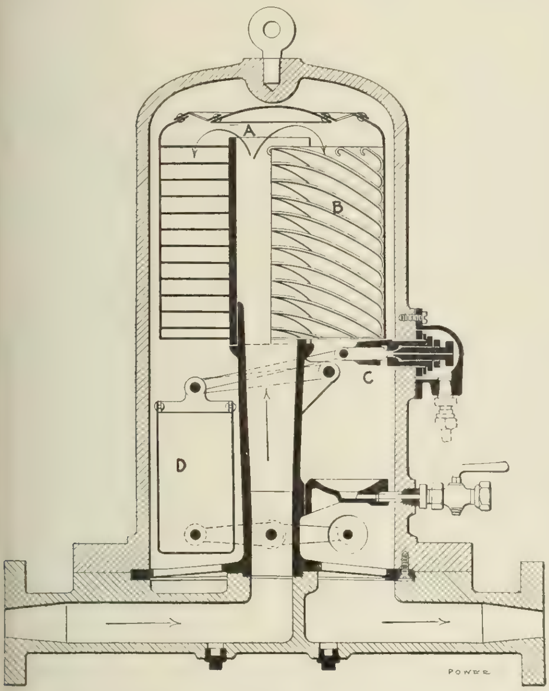
The Cost of Unloading Coal from vessels into elevated coal bunkers or storage piles has been reduced by the New York Edison Co., in New York City, from more than 25c. per ton originally to a present cost of not more than 2c. per ton, where trimming in the pile or bunker may be left out of the question. This, according to George A. Orrok, in a paper read before the American Society of Mechanical Engineers, is the result of an extensive study of the question of coal handling on piers and involves mechanical handing equipment properly designed for this purpose.

"Airex" Automatic Feed-Water Air Extractor

This device is designed to be installed in the boiler feed-line to eliminate air from the feed water. Water contains about 2 per cent. of air, which is carried to the boilers with the water and is contained in the steam leaving the boilers.

To facilitate the air extraction, the apparatus is installed near the boiler in the hot feed-water line, as hot water gives up the air easier than the cold water.

By eliminating the air, corrosion of the boiler tubes is prevented, involving less repair cost and fewer shutdowns. Another advantage of the apparatus is that less air reaches the condenser and a higher vacuum will result. The increase of the vacuum, however, cannot be given in exact figures, as the conditions vary largely.



Section through "Airex" Air Extractor

The automatic float valve, with which the air extractor is fitted, is placed so far below the highest point in the air vessel that when starting with atmospheric air in the air vessel and a leaky valve, the surface necessary for eliminating the air is not diminished. For this purpose, and also for removing the air as completely as possible, the feed water enters the apparatus at the highest point *A* of the air vessel, at a low velocity, and spreads in a thin film over the distributing surfaces *B*.

The discharge of the water into the distributing surfaces is placed so high above the air valve *C* that there are sufficient surfaces exposed for eliminating the air.

Air, gradually collecting in the air chamber, under a pressure equal to that in the boiler, causes the water level to sink until the float *D*, acting on the air valve *C* through suitable levers, opens the air valve and relieves the chamber of air. As the float is of the open type, it is not subjected to external pressure. It is so arranged that the valve only opens when the water level has sunk about 4 in. below the air valve. This arrangement prevents dirt and oil from clogging the air valve.

When the apparatus, which is manufactured by the General Condenser Co., 1239-1257 North Twelfth St., Philadelphia, Penn., is in continuous use the water level will automatically remain at a constant height. By a special arrangement the oil and floating dirt can be drawn off.

*

Steam Railway Electrification*

Power companies are interested in electrification because they have electrical energy for sale. The railway companies can build and operate their own power plants, but in many cases they find it cheaper to buy energy than to generate it, the low ratio of average demand to maximum demand, making a railway load alone, rather unprofitable for a power station.

SYSTEMS OF ELECTRIFICATION

As far as the power station and transmission lines are concerned, nearly all systems of electric traction are similar, consisting generally of three-phase power generation and high voltage and three-phase transmission. It is in the motive power equipment and the distribution systems that the differences come. Four systems are finding practical application today.

DIRECT-CURRENT SYSTEM—In this system direct-current series motors are used on the locomotives or motor cars and voltages ranging from 600 to 2400 volts are used on the trolley or third rail. The trolley or third rail and its feeders receive direct-current energy from substations located at intervals along the right of way. In the substations, transformers and rotary converters change the high-voltage three-phase currents of the transmission system to direct current at the proper trolley voltage. This is the well known system used on street railways, modified to meet the demands of steam line traffic and up to the present time has found wider application in this country than all of the other systems put together. Of interest in connection with this system is the recent announcement that the Chicago, Milwaukee & Puget Sound Ry. has decided to use it in its electrification over the Rocky Mountains.

SINGLE-PHASE SYSTEM—Either series or modified repulsion type, single-phase motors are used on the locomotives or motor cars. The trolley receives its single-phase current supply from transformers, located at intervals along the line, which transform the high voltage of the transmission system to a value suitable for the trolley. Trolley voltages range from 3300 to 25,000 volts, 11,000 volts being common in this country. A balanced three-phase load is approximately secured by dividing the trolley line into sections and feeding the different sections from different phases. Transformers on the locomotives or motor cars step the trolley voltage down to a value suitable for the motors. The motors are rather complicated and have high maintenance charges. On account of the high trolley voltages used, the first cost and line losses of the distribution system are low. The most prominent example of this system, in this country, is that of the New York, New Haven & Hartford Ry.

THREE-PHASE SYSTEM—In this system three-phase induction motors are used on the locomotives and two trolley wires are required, the track forming the third leg of the three-phase circuit. Trolley voltages up to 11,000 volts have been used. Transformers on the locomotives step the trolley voltage down to a value suitable for the motors.

The two trolley wires required complicate the overhead work, but the motors are simple and rugged. The system is readily adapted itself to regenerative control of trains on down grades. The motor is inherently a constant speed motor and will carry its load up grade approximately as fast as it will carry it down grade or on the level. With some modifications in the design of the motor, its speed can be varied in steps without seriously affecting its efficiency.

The Great Northern's Cascade Tunnel electrification is the only example of this system in this country although locomotives having an aggregate rating of about 200,000 hp. are in use in Europe.

SPLIT-PHASE SYSTEM—The locomotives are equipped with polyphase motors and single-phase current is supplied from the trolley. A phase converter on the locomotive converts the single-phase energy to the polyphase energy required by the motors. The distribution system is the same as with the single-phase system, and the motive power equipment is the same as with the three-phase system with the exception of the phase converter. In a measure the good points of both systems are combined. The system is a new one and is possibly the most spectacular development in electric traction made during the year just passed.

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*Excerpts from a paper by Prof. D. D. Ewing delivered before a recent meeting of the Indiana Engineering Society.

ADVANTAGES AND DISADVANTAGES OF ELECTRIC TRACTION

The following are a few of the more important advantages and disadvantages of electric traction for railway trains. Briefly, the advantages are:

The safety of operation is increased because signals are not obscured by smoke and steam, and the locomotive driver can give his entire attention to driving and his seat can be located so that he can see both sides of the track at all times.

Regenerative control is possible with all systems of electric traction. With regenerative control the air brakes are used only in stopping or in case of emergency. Car wheels and brake shoes are not heated by long continued applications of the brakes on down grades and the number of wrecks due to cracked wheels is lessened. The energy that would otherwise be used up in heating the brake shoes and wheels is pumped back into the line and helps pull some other train up hill. While regenerative control is possible with all systems, it has not been used on all systems in the past on account of the resulting complication in the control apparatus and motor windings of series type motors.

The dispatcher can stop a train at any time by ordering the power supply shut off from the section in which the train is running and the control mechanism may be readily arranged so that the brakes are applied automatically if the power is shut off from the trolley.

In mountain grade work, higher speeds may be maintained over the grades than is possible with steam locomotives. Going upgrade the speed of the steam locomotive is limited because its power output is limited by the boiler capacity. The electric locomotive is not limited in this way and for short intervals it can carry large overloads.

Powerful motors can be mounted on comparatively light locomotives. While the weight of a locomotive fixes the drawbar pull at starting, its horsepower capacity fixes the pull when running at a given speed. This means that electrically operated trains can be accelerated at much higher rates than steam trains and can be operated at higher speeds over grades.

Electric locomotives require inspection once in from 1200 to 2500 miles of operation. To keep steam locomotives in similar condition they must be inspected and cleaned at the end of every run. On those roads which are operating electric locomotives, the daily mileage of the locomotives is from 25 to 50 per cent. greater than the steam locomotives which they replaced, and their reliability is indicated by the fact that the delays chargeable to motive power are less than 50 per cent. as compared with steam motive power.

Experience has shown that the fuel cost with electric operation is from 40 to 75 per cent. of that with steam operation. There are no standby losses. Prof. Goss has estimated that one-fifth of the coal burned under locomotive boilers is burned while the locomotives are standing on sidings, or in starting fires.

The first cost of electrification is high as compared with the first cost of steam motive power. The cost of steam motive power for the average steam road is about $2000 per mile of single track, while the cost of electric motive power runs from $7000 to $12,000 per mile of single track. The cost of terminal electrifications may be even higher.

Power house accident might put a whole railway system out of commission. The dependence of the electric locomotive on the power house tends to make it inflexible in some respects.

Steam locomotives have passed through the development stage and are practically a standard product. They have developed to their present perfection through a period covering nearly a century. They are reliable and remarkably efficient, considering the conditions under which they operate, and their characteristics and limitations are well understood by a majority of the operating men. On the other hand, electric traction as applied to railway trains is scarcely two decades old. Progress in the electric arts has been so rapid during the past quarter of a century that apparatus which today represents best modern practice is likely to be on the scrap heap tomorrow, not because it is worn out, but because it is obsolete.

Long continued overloads overheat and burn out the electrical equipment. Such overloads are common in railwa service and do not seriously injure a steam locomotive. I the overload on a steam locomotive is too great, it simpl stops work, and no serious injury results.

As the rails are used as part of of the main power circui the signal circuits for electric block signals and for interlocking plants are more complicated and expensive to maintain.

While no trainmen within the motor cars or locomotive have been killed or seriously injured, there have been a fe fatalities among the men employed outside.

The losses, in a poorly designed transmission and di tribution, may amount to as much as the power actuall used to operate the trains.

In general it may be said that no one system of electr traction is best adapted to all classes of service. The d rect current system seems best adapted to terminal wor where a large number of trains are operated and where, o account of the large number of stops per mile, rapid accelerations are necessary. On account of the denseness of th traffic the substations may economically be placed close together, and as the distances are short, transmission losse are low. As far as fulfilling the general requirements railway service is concerned, the series direct-current moto is the best motor available. But its use is limited because it cannot be operated at high voltages; low voltage on the trolley mean high line losses. Likewise, the alternating-current systems with their high trolley voltages an low line losses, and motors which lack the powerful startin torque of the direct-current series motor, seem best adapte to long trunk-line service where the stops are few and th accelerating period is short as compared with the total tim of the run.

* * *

The Roanoke Dam Bill

A tilt between Gifford Pinchot and Secretary of War Ga rison recently led to the withdrawal by the latter of his a proval of the Roanoke River Dam Bill, introduced by Senat Martin of Virginia, and the announcement of what is to b the administration policy as to the damming of navigab streams and the granting of franchises to hydro-electr power companies.

The Roanoke Dam bill had been reported to the Senat and would probably have come up for consideration within few days, when Mr. Pinchot, as president of the Nation Conservation Association, issued a public statement decla ing the measure to be the most serious blow yet struck the conservation policy. Under date of Jan. 17, Secreta Garrison had written a letter to the Senate committee givin unqualified approval of the bill.

"The Roanoke River dam bill," said Mr. Pinchot in h statement, "makes no provision for payment to the publ in return for the great values it turns over to private hand It provides no safeguards against either monopoly or e tortionate charges to the consumer. On the contrary, it is entire accord with the demands of the water power men wh were so overwhelmingly defeated at the recent National Co servation Congress. The bill embodies exactly what the water power interests have been contending for ever since halt was called upon giving away public water powers navigable streams by the presidential veto of the Jame River bill in 1909. Most of the reasons which led to th veto, and all of the reasons which moved President Taft veto the Coosa River dam bill, are effective against this bi The passage of the Roanoke River bill would clear the wa for the enactment of the indefensible Coosa River bill i self. In addition, 17 other similar bills have already bee introduced and are awaiting the result of action upon th one. To enact it would be a needless surrender to special i terests at a time when the water power fight is practicall won."

This statement brought from Secretary Garrison a promp repudiation of the letter in which he had given endorseme to the Roanoke River bill. He announced that he agre with Mr. Pinchot in his estimate of the measure, and ha signed the letter of approval perfunctorily, without realizi its real import.

This incident provoked so much discussion that a Cabin meeting on the following day was devoted to threshing o the water power and dam question. Serious differences opinion were discovered among the President and the Cabin on the subject, mainly as to whether the Federal governme should regulate and control all power sites and plants navigable streams, or whether the claims of the state gover ments to recognition in this respect should be conceded. policy was finally agreed upon, in which an effort is made recognize so-called "states rights," and at the same time assert Federal rights and authority over dams and dam sites.

A bill announced to embody the ideas of the President has been sent to Congress, and will form the basis for consideration by the sub-committee on dams recently appointed by the House Committee on Interstate Commerce. This bill was accompanied by a letter from Secretary Garrison explaining the policy of the administration, which, despite the explanation, still remains a trifle hazy, as its main effort is to draw a line in what President Roosevelt called "the twilight zone" between Federal and states authority.

The proposed general dam bill is to apply only to dams and power plants built along navigable rivers within states, or between states. It does not affect the granting of power sites in the public domain. Secretary Lane, of the Department of the Interior, has announced his belief that power plants in the public domain should be built by the government itself, and until public sentiment is ready for such a course, he wants grants made under which the plants will revert to public ownership after a term of 20 years or less.

Under the proposed general dam bill, it is suggested that dam sites and franchises shall be granted only to properly incorporated utilities corporations, which must first obtain consent from the states in which the dam sites are located, and afterward obtain the consent of Congress. Such grants are to be made only in states which have laws for the regulation of utilities and their charges and operations, including the regulation of rates. Where these conditions are complied with, the Secretary of War may issue a permit for the damming of a stream, the grant to be for not longer than 50 years. Both the War Department and the Congress retain authority to regulate such operations of the dam company as may affect the navigation or navigability of the stream. The bill also proposes that where the government has built navigation dams at which hydro-electric power may be incidentally developed, the Secretary of War shall have authority to permit the use and development of this power by public utility corporations under state incorporation and regulation.

As to what restrictions, if any, shall be placed by Congress upon the regulation of dam companies by the states in which they operate, the bill has no provisions. In his letter, Mr. Garrison said that there were so many opinions as to this phase of the matter that he left the matter for Congress to determine. In his opinion, the states should derive some revenue from dams and power plants so built, and he offers, as optional plans, that the states may be allowed to tax the plants, or otherwise provide that the plants shall become the property of the state in which they are built, at the end of a specified period.

The general dam bill is reasonably certain to provoke a controversy between the states-rights advocates and the group of conservationists headed by Mr. Pinchot, who believe that the Federal Government has and should retain complete control over all dams built in navigable streams.

* * *

New York Boiler Inspectors Dine

About 200 members and guests of the New York Association of the American Institute of Steam Boiler Inspectors enjoyed the third annual banquet of the association at the Fifth Avenue Restaurant, New York City, Saturday evening, Feb. 21. The following officers were installed: President, James Gillespie; vice-president, Robert Thomson; secretary, J. H. Pollard; treasurer, George Turnbull; James H. Kinkead is chairman of the executive committee.

Mr. Young, president of the Boston Association, said that the Board of Boiler Rules of Massachusetts had requested his association to comment on the proposed rules of the board. The request was granted and the comments and recommendations of the inspectors gladly accepted. Michael Fogarty, in speaking of a comprehensive boiler law for New York state, said that the legislative committee which the inspectors met at Albany consisted of nine lawyers, a couple of storekeepers, a saloon keeper, etc.—a 57 variety kind.

Mr. Brown, secretary of the new Buffalo association, reported the progress made by the inspectors in Buffalo. Mr. Van Winkle, of the Travelers Indemnity Co., told of the pensioning of old inspectors by his company. He stated that one need not fear that state boiler laws would eliminate the insurance company's inspectors.

F. R. Low, editor of "Power," reviewed the progress of the uniform boiler laws committees of various engineering organizations. He also quoted interesting figures on the life of steam boilers in Switzerland. Some of these boilers are over 60 years old and are still giving service under reasonably high pressure.

Mr. Hansen, secretary of the Workman's Compensation Commission of New York, spoke interestingly on the amount collectible by those injured and by beneficiaries of those killed in boiler explosions now that the workman's compensation law is soon to be enforced in New York State. In 40 years over 10,000 persons have been killed in boiler explosions in the United States. Under the workman's compensation law this would represent about $50,000,000 in damages for those killed. The fact that only one boiler in ten of those exploded was inspected by insurance companies demonstrates the value of systematic inspection.

Mr. Hansen stated that although there were fewer boiler explosions in Europe, America was first to propose comprehensive boiler rules, for he remembers when the rules chiefly used in Europe were those formulated by the Hartford Steam Boiler Inspection & Insurance Co. State boiler inspection has many virtues, but to be of real value it must always be independent of politics.

Other speakers were Messrs. Idel, Banks and James White.

Mr. Thompson, the retiring president, was presented a beautiful silver-mounted, stag-handled umbrella. A feature of the speaker's table was a full-equipped model of a Babcock & Wilcox single-drum boiler.

* * *

Electric Veterans Organize

On Saturday evening, Feb. 21, the employees of the Westinghouse Electric & Manufacturing Co. who have been with it for 20 years or more, held a meeting and organized the Veteran Employees Association of the Westinghouse Electric & Manufacturing Co. A business meeting was held and officers were elected for the ensuing year. Following a dinner was an interesting program consisting of speeches and vaudeville. The toastmaster was L. A. Osborn, vice-president of the company. A striking fact was the youthful appearance of these so called veterans, the majority appearing to be men in the prime of life.

About 325 employees are eligible to membership, and approximately 315 were present at this meeting. President Herr, in the course of his remarks, promised the support of the company to the organization, and stated that the officials were working on pension plans for the employees, details of which will be announced later. Other speakers were: Chas. A. Terry, vice-president; and James J. Barrett, representing the shop. Mr. Terry gave several interesting reminiscences of the developments which have occurred during his experience of over a quarter of a century with the company.

Guy E. Tripp, chairman of the board of directors, was present and was elected an honorary member, as was President Herr, neither having been connected with the company the required 20 years. A standing toast was drunk to George Westinghouse, who was unable to be present on account of illness.

NEW PUBLICATIONS

FACTORY ORGANIZATION AND ADMINISTRATION. By Hugo Diemer. Second edition; 378 6x9-in. pages; 174 illustrations. Bibliography; indexed; cloth bound. Price, $3. McGraw-Hill Book Co., New York City.

This second edition of a well received book on industrial management contains some 70 pages more than in the first printing. In the work of enlarging, the volume has been, to a large extent, rewritten and extensively rearranged, to bring about a more logical sequence. This has been necessitated by the important development in industrial management, since the book was first issued. The paragraphs are now numbered and are given topical headings. At the end of most of the chapters is a reference to specific chapters or sections of modern books, the transactions of engineering societies and articles that have appeared in the technical press. These changes will make it more useful and of more help to anyone who wishes to pursue the study of the subject further.

* * *

Bagged Boiler Photographs—For use in educational work, W. V. Ford, 1046 East 79th St., Cleveland, Ohio, is desirous of securing good photographs of boilers and boiler tubes that have been bagged from deposits of oil on the tubes and shell, and will gladly pay well for any that are sent him which may prove suitable for his use.

Winnipeg Hydro-Electric Developments

The J. G. White Engineering Corporation, New York, has been engaged by the Winnipeg Electric Ry. to complete surveys, explorations, designs, plans and estimates for a large hydro-electric development near Winnipeg, Canada. It is understood that the ultimate development will considerably exceed 100,000 hp., and that the immediate development, for which complete designs and plans are to be prepared, will be for 10,000 hp. Work on the surveys, explorations and designs is to be started immediately and completed as rapidly as possible.

The Winnipeg Electric Ry. Co. was formed by a consolidation of the Winnipeg Electric Street Ry. Co. and the Winnipeg General Power Co. The outstanding capital stock is $9,000,000. The directors include Sir William Mackenzie, who is president and a large owner, as well as well known citizens of Winnipeg, including William Whyte, vice-president, and F. M. Morse, secretary and treasurer. The directors include also H. S. Sutherland, Winnipeg, Sir William Van Horn, Montreal, and Sir Donald Mann, Toronto.

It is understood that there was considerable competition for the work just awarded, and that this was finally given to the J. G. White Engineering Corporation because the directors were convinced that this corporation had an exceptionally experienced staff of engineers and construction superintendents for handling this class of work, and the preliminary designs submitted appealed to the directors as suggesting the most advantageous plan for developing the enormous water power.

Civil-Service Opportunities

COMPETITIVE EXAMINATIONS *for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commissions. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.*

Situation for Gas Engineer—The Philadelphia Civil Service Commission will hold an examination, Mar. 21, for the position of gas engineer in the Bureau of Surveys, Department of Works. Salary, $1000 per year. Address the Civil Service Commission, Room 875, City Hall, Philadelphia, Penn.

Situation for Engineers—The Philadelphia Civil Service Commission will hold examinations, Mar. 21, for three positions of power-plant or stationary engineer. Salaries, $1500 to $1800; less than $900, and $900 to $1200 per year. Address the Civil Service Commission, Room 875, City Hall, Philadelphia, Penn.

Situation for Engineer—The Philadelphia Civil Service Commission will hold an examination, Mar. 27, for the position of engineer in charge of boilers in the Water Bureau of the Department of Public Works. Salary, $1500 per year. Address the Civil Service Commission, Room 875, City Hall, Philadelphia, Penn.

Situation for Engineer—The Philadelphia Civil Service Commission will hold an examination, Mar. 21, for the position of operating engineer in the Water Bureau of the Department of Public Works. Salary, $1000 per year. Address the Civil Service Commission, Room 875, City Hall, Philadelphia, Penn.

SOCIETY NOTES

The proposed consolidation of the engineering courses in the University of Pittsburgh and the Carnegie Institute of Technology was discussed informally during the recent visit to the city of Dr. Richard C. Maclaurin, president of the Massachusetts Institute of Technology. No definite action was taken. As Dr. S. B. McCormick, chancellor of the University of Pittsburgh, is abroad it was impossible to get an expression from the authorized representatives of the two institutions. Dr. Maclaurin declared that he came to Pittsburgh to attend an alumni reunion of Massachusetts Tech and would not venture an opinion as to the feasibility of a union of the two schools similar to the consolidation of the Massachusetts Institute of Technology and the engineering department of Harvard University.

On Tuesday evening, Feb. 17, Illinois Association No. 1 of Chicago was visited by the officers and trustees of the National Association of Stationary Engineers. The officers on the night of the meeting had just returned from Milwaukee, where they had met and conferred with the national convention committee on the arrangements for the next annual convention in September. At the preliminary business session Jacob Reitz presented President Hays a handsome cut glass punch bowl set, a wedding present from his brothers of the order. At the close of the business session the doors were thrown open and the meeting turned over to Past President John F. McGrath. H. Misostow introduced the speakers of the evening. National President, James R. Coe, gave a long address on the good of the order, and incidentally predicted a record-breaking convention in Milwaukee. William J. Reynolds, trustee, gave some statistics on "The National Engineer," and the convention was again touched upon in short addresses by the president and secretary of the National Exhibitors Association. W. L. Parker, Elgin, Ill., extended a royal welcome to the national officers. Alfred Johnson spoke briefly on the educational work of the association, and Past President McGrath gave the closing talk of the evening.

Dr. W. M. Davidson, superintendent of public schools of Pittsburgh, told the Pittsburgh section of the American Institute of Electrical Engineers at the Fort Pitt Hotel, Feb. 14, that he represented the American Educational Engineers, Pittsburgh branch. He asked for the sympathetic coöperation and generous support of the electrical engineers in the educational work of Pittsburgh and said that the aim of those directing the Pittsburgh schools was to bring them to a degree of efficiency not equaled by any others. Paul M. Lincoln, of the Westinghouse Electric & Mfg. Co., dealing with the cost of electric service, said that there was much misconception concerning rates; that the cost of electricity to the public is fixed by the cost of the service added to a legitimate profit. He said it was easier to supply a small number of large consumers than a large number of small consumers, and for this reason rates for service in residences were necessarily higher than those for factories. C. O. Mailloux, of New York, president of the Institute, was the guest of honor and spoke on "The Institute." He said that the coöperation among electrical people that the institute had encouraged, was its most beneficial result. The toastmaster was Samuel M. Kintner, vice-president and general manager of the National Electrical Signaling Co., who is engaged in wireless telegraphing work with Prof. F. A. Fessenden. George P. Early, of the American Sheet & Tinplate company, delivered a humorous talk on "Stomatology." The banquet was attended by 300 members.

OBITUARY

EDWIN M. HALL

Edwin M. Hall, treasurer of the Jefferson Union Co., Lexington, Mass., died on Wednesday, Feb. 11.

EUGENE McSWEENEY

Eugene McSweeney, president of the United States Graphite Co., Saginaw, Mich., died at Hot Springs, Ark., on Mar. 1.

Mr. McSweeney was born in Kalamazoo 46 years ago, and started his career selling newspapers. His life had many hard setbacks, but he fought the uphill battle until he reached the top. At his death he had been not only successful as a newspaper publisher, but made a thriving venture of the United States Graphite Co.

Mr. McSweeney entered the newspaper field in Kalamazoo. When of age he became identified with the "Kalamazoo Gazette." In 1891 he came to Saginaw on the old "Evening News." After a short time he returned to Kalamazoo, and six months later came to Saginaw and became treasurer and general manager of the paper, and part owner with John T. Winship, now state insurance commissioner.

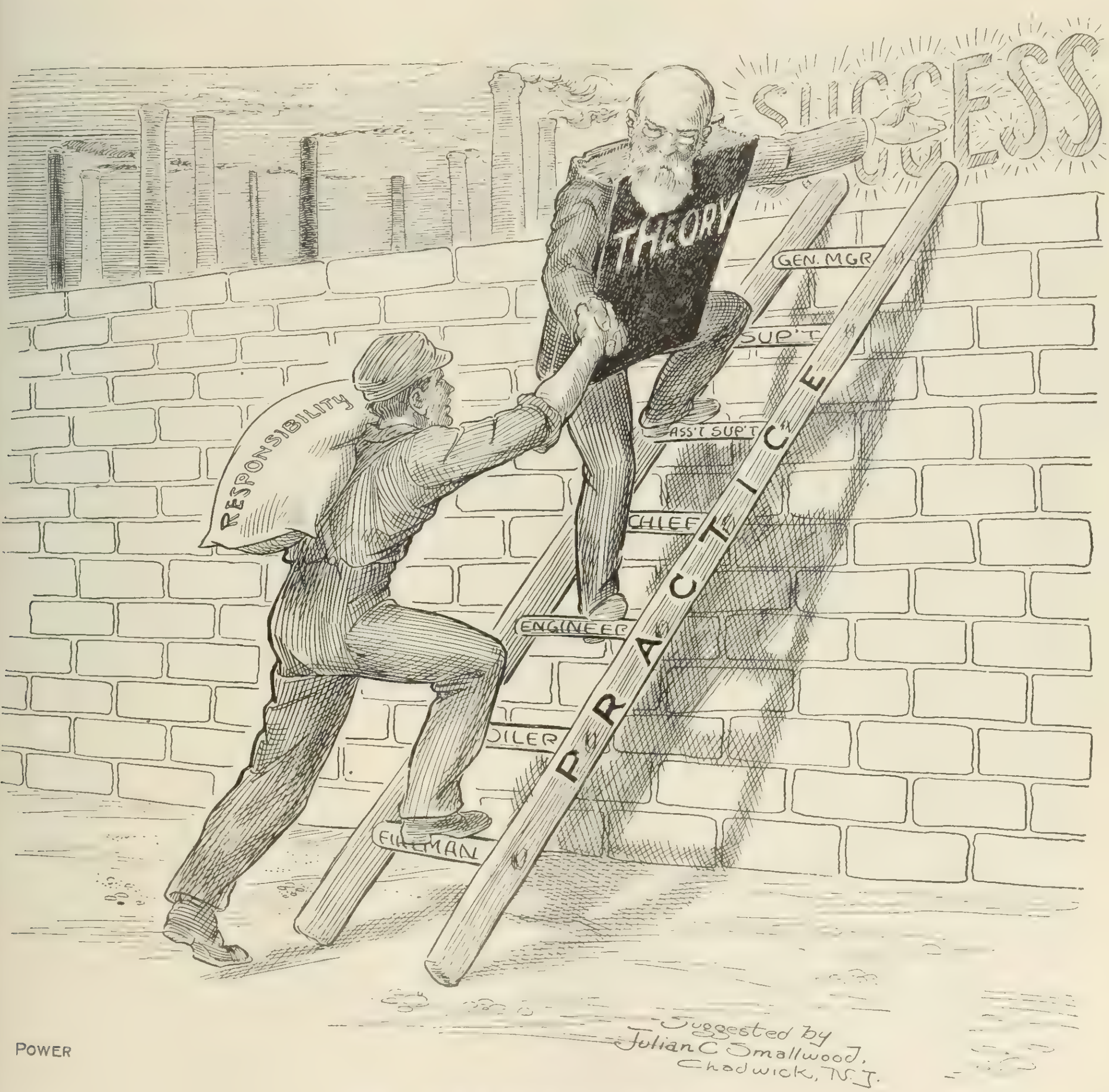
Messrs. McSweeney and Winship conducted the paper on a successful scale, building it from a meager to a prosperous institution. In 1910 the paper was sold to the present owners. Four years previous Mr. McSweeney had given up active management of the paper, becoming president of the United States Graphite Co. Today the company is the largest of its kind in the world.

Mr. McSweeney was active in civic life. He served as president of the Board of Trade, the Saginaw Club, and was identified with several manufacturing institutions.

Charity was one of the big sides of Eugene McSweeney. While unostentatious, his alms reached scores of needy. His heart was big and he gave with a free hand. He leaves a widow and two children, Eugene and Hanna.

POWER

Vol. 39 NEW YORK, MARCH 17, 1914 No. 11



POWER

A HELPING HAND

[*See Editorial on page* 380]

Hydro-Electric Plants of the Tennessee Power Co.

By Warren O. Rogers

SYNOPSIS—These two hydro-electric developments have a total capacity of 45,000 hp. The features of No. 1 plant, at Parksville, Tenn., are the 110-ft. high concrete dam, five 5000-hp. turbine waterwheels, and the manner of housing them within the dam. No. 2 development consists of a crib dam 32 ft. high, a wooden flume five miles long supported on a bench, cut in the mountain-side at some places, and at others by trestle work. Two 8-ft. penstocks supply water to two 10,000-hp. waterwheels at a 250-ft. head. Several steam plants are controlled by the company, making a total of 85,000 hp. now available. Additional water power of 115,000 hp. can be developed, as required, making a total of 200,000 hp. available for future use. Electrical energy is transmitted 13½ miles at 60,000 and 120,000 volts to the switch-house at Cleveland, whence it is sent out to several cities.

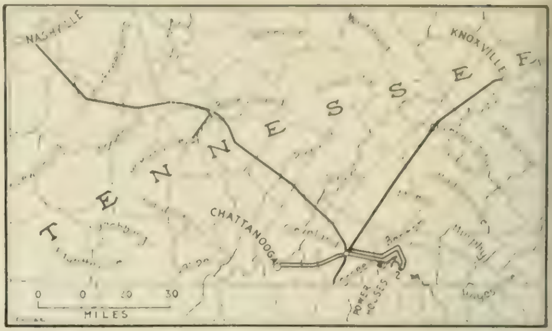


Fig. 1. Transmission Lines and Power-House Sites

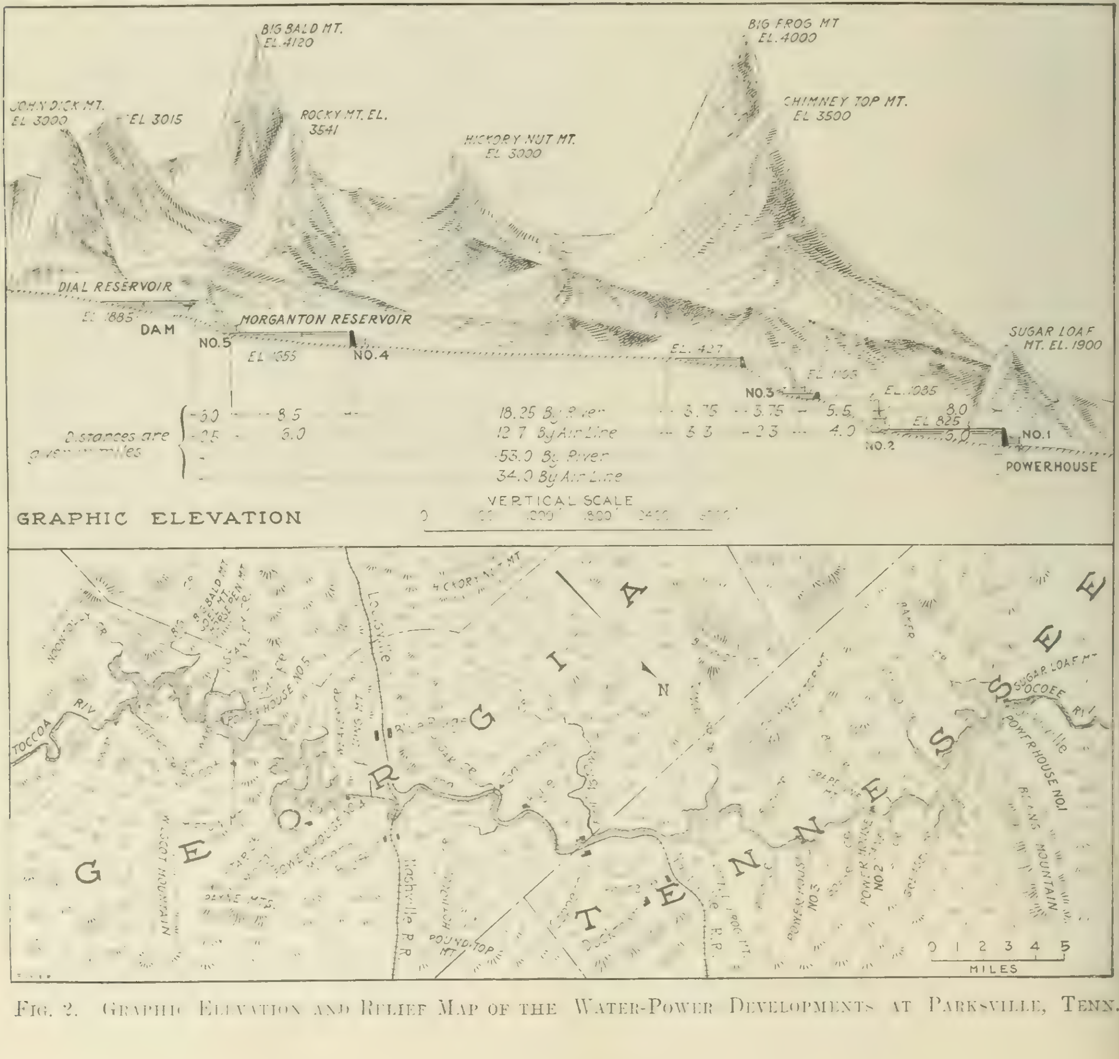


Fig. 2. Graphic Elevation and Relief Map of the Water-Power Developments at Parksville, Tenn.

The second hydro-electric plant of the Tennessee Power Co., on the Ocoee River, in the Appalachian Mountains of southeastern Tennessee, near Parksville, which was put in operation Oct. 23, 1913, marks an important step in the industrial development of that part of the South. This plant, together with the other, 10 miles away, on the same river, will ultimately produce a total of 55,000 hp.

The water resources of the Tennessee Power Co. are principally located between Parksville and Ducktown, on the Ocoee River, in eastern Tennessee, and on the Collins and Caney Fork rivers in middle Tennessee.

It is with the Ocoee River development that this article deals. The river rises in the Appalachian Mountains at an elevation of 2025 ft. above the sea level and has a watershed with an average annual rainfall exceeding that of any other part of the United States excepting Oregon and Washington.

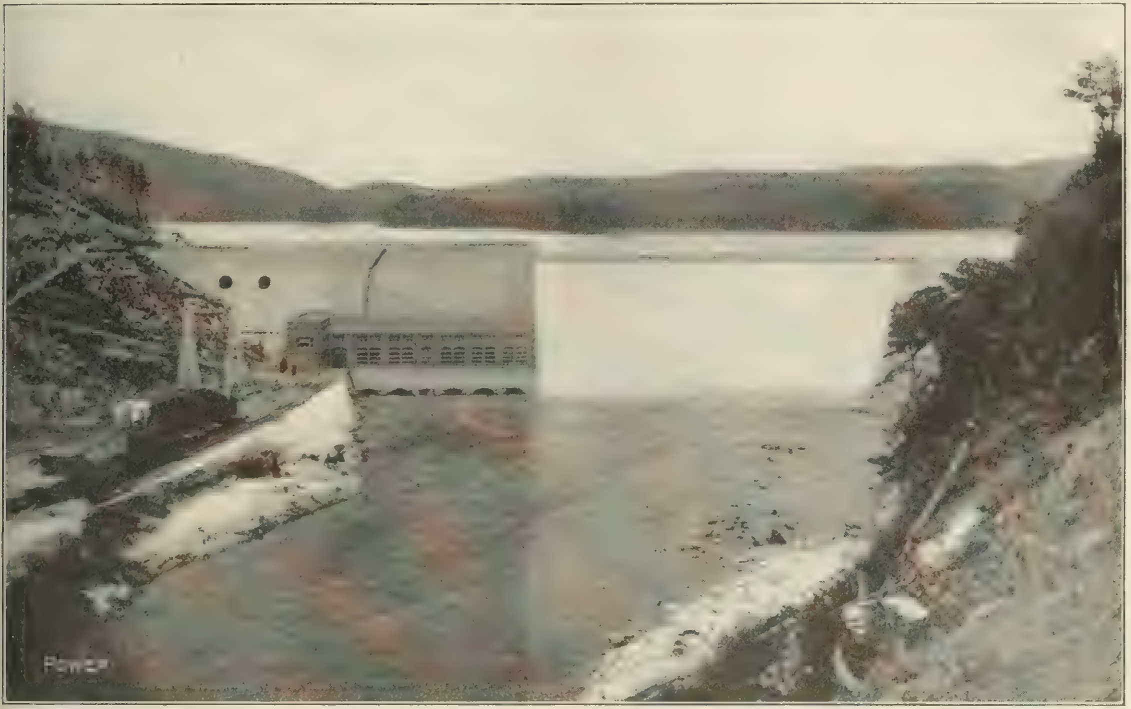


FIG. 3. DAM AND POWER HOUSE OF NO. 1 DEVELOPMENT

Two miles below Ducktown, the Ocoee River enters a narrow gorge, follows it for 15 miles, then flows through a wide valley to a narrow gateway between Sugar Loaf and Bean Mountains. The waterway between Ducktown and Parksville, a distance of 26 miles, is owned by the company. In this distance the river has a total fall of 710 ft. which will be utilized in three plants, two of which are now in operation. A study of the map, Fig. 1, gives a good idea of the location of the two power sites, the development near Rock Island, and the route of the transmission lines.

In Fig. 2 is shown a graphic elevation and relief map of the three Ocoee developments. At the extreme right is the Parksville dam and the lake formed thereby. The surface of this lake is approximately 2000 acres and is at an elevation of 825 ft. above sea level. Just above the lake is the power house of the No. 2 development. The wooden flume, shown by dotted lines, runs from the dam, five miles above, to the power plant. The third development will consist of a dam and lake 1372 ft. above sea level. It will contain three 10,000-hp. units.

The preliminary work on the two power plants, now completed and in operation, was begun in May, 1910, and actual construction begun in August of the same year. The work was carried on by the Tennessee Power Co., with J. G. White & Co. as engineers. The cost of the two developments was approximately $5,000,000. The main feature of No. 1 development is the concrete dam; that of the other, a five-mile flume built along the mountain-side.

Building a hydro-electric plant is usually more difficult than a steam plant, because of the remoteness of the power site from transportation facilities. The developments on the Ocoee River were no exception. In fact, the conditions were exceptional, and completing these developments was a difficult proposition, both from a financial and an engineering standpoint. For instance, it was necessary to build about seven miles of narrow-gage railroad, operate a fleet of boats and barges to transport the material from No. 1 power plant up the lake, formed by the dam, to the site of No. 2 development. Here an incline was constructed for hoisting material 300 ft. up to the line of the flume. About 15 miles of power-transmission line were also constructed.

Development No. 1, at Parksville, Tenn., consisting of a dam and a generating station, has been in operation two years. The dam, known as a gravity type, is 110 ft. high at the spillway section, and 840 ft. long from bank to bank. The spillway section is 230 ft. long. The structure contains 160,000 cu.yd. of concrete. A view of the dam and power plant is shown in Fig. 3.

The dam is built across a gorge between Sugar Loaf and

Bone Mountains. The spillway is built in an arc of a circle, made necessary because of the formation of the bed rock of the river. The spillway is designed to discharge all excess water at the highest flood stage of the river. In addition to the spillway there are two sluice gates with a discharge capacity equal to the normal flow of the river.

Referring to the sectional view of the dam and power house, Fig. 4, the penstocks are encased in the concrete work of the dam and lead to the waterwheels, discharging the water at a point above the wheel vanes. At the rear of the waterwheels a tunnelway has been provided for access to the rear turbine-shaft bearings and to the hand-operated sluice-gate gear. There is a vacuum of 15 in. in the waterwheel draft tubes. The operating mechanism for the double penstock gates is mounted at the top of the dam and is operated by 10-hp. direct-current motors, controlled from the power-house switchboard.

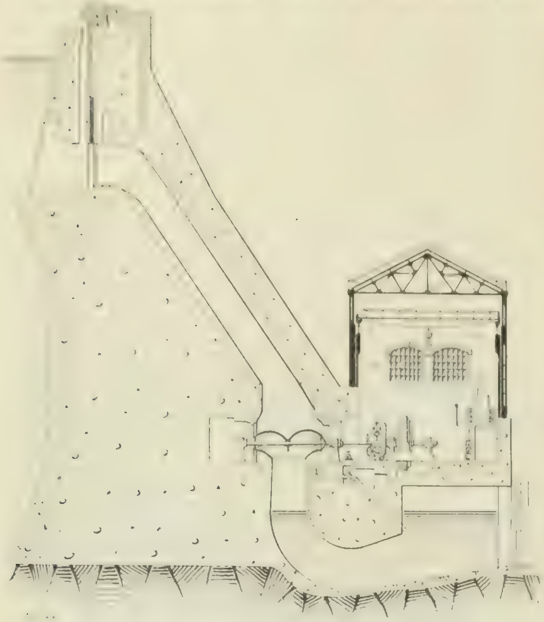


Fig. 4. Cross-Section of Dam and Power House No. 1.

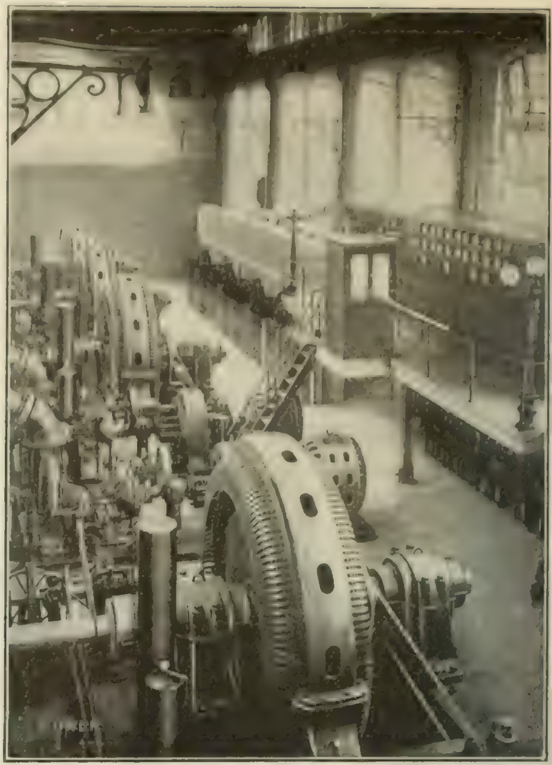


Fig. 5. Interior of No. 1 Power House

No. 1 Power House

The brick building, constructed with an ell, is built parallel with and at the base, at one end of the dam. The five generators, of 3750 kv.-a. capacity, generating 2300-volt, three-phase, 60-cycle current, are in the main part of the building. The generators are directly connected to the five 5000-hp., horizontal, double-wicket 39-in. gate

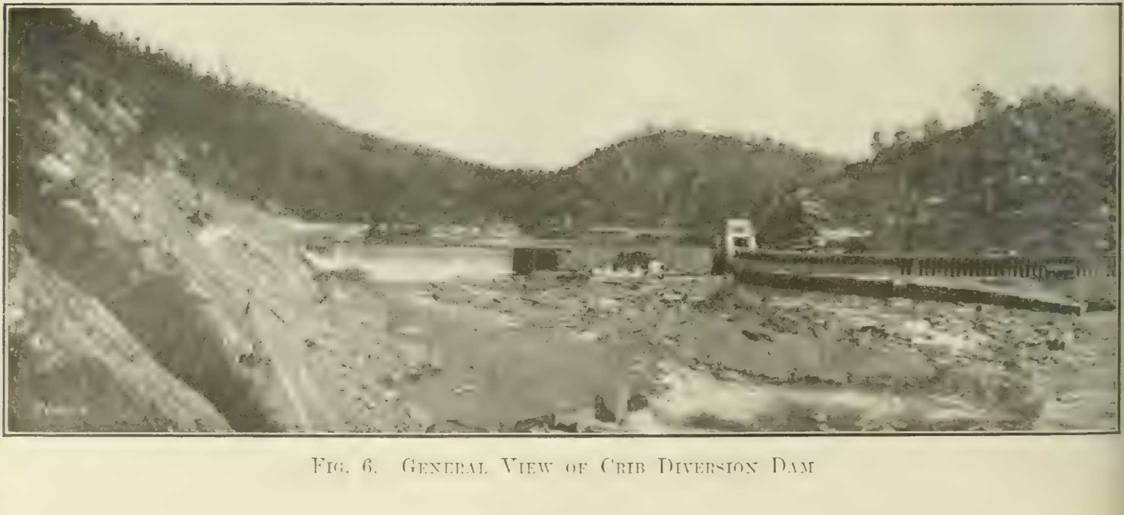


Fig. 6. General View of Crib Diversion Dam

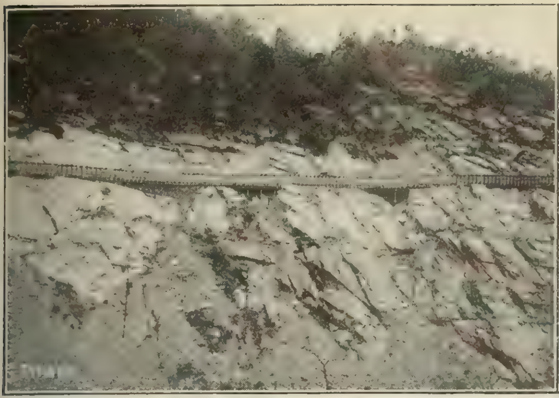


Fig. 7. Flume on Mountainside

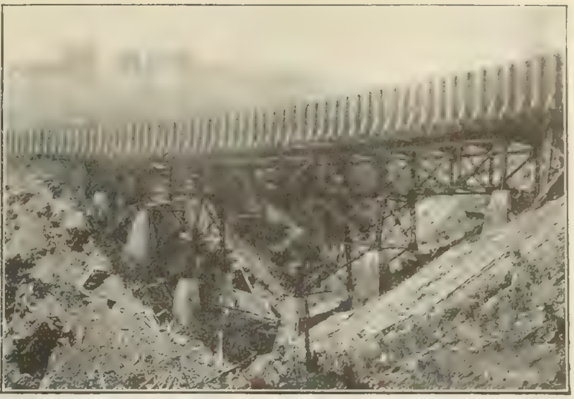


Fig. 8. Steel Trestle and Flume

turbines, which run at 360 r.p.m. Fig. 5 shows the generator room.

The speed of the turbine wheels is governed by oil-pressure-operated governors, equipped with an emergency safety device for closing the inlet water gates in case of accident.

There are two 125-volt exciter sets of 120 kw. capacity, either of which is of sufficient capacity to excite all of the generators; each are driven by 250-hp. wicker-gate waterwheels at 580 r.p.m. Mounted on the end of the shaft of each exciter unit is a 200-hp., 2300-volt induction motor, which floats on the line and gives close regulation to the excitation voltage. As there is a coupling between the turbine and motor and the exciter generator they can be disconnected and the exciter generator operated while either the turbine or the motor is cut out for repairs. The speed of the exciter turbines is regulated by governors of the compensating type.

The generators are at one side of the room, with the shaft extending through the side wall to the turbines, which are outside the building and are housed in the dam. The exciter waterwheels, however, are in the generator room. Riveted-steel penstocks protrude through the side wall and connect with the turbine casings at the top.

On the opposite side is a switchboard balcony, under which are the low-tension oil switches; the distributing busbars are back of them. A brass miniature busbar circuit is attached to the front of the slate-panel switchboard. All switches are provided with a bell alarm and are operated by remote control.

The high-tension transformers, the high-tension room and the office are in the ell of the building. The five 3750-kv.-a., 2300-66,000-volt, three-phase transformers are water cooled. Two gravity sources of water are available for this purpose, one from a spring on the mountain, the other from the lake above the dam. The transformers are in compartments which are fitted with rolling steel doors.

Disconnecting switches are arranged on each side of the high-tension switches; the transformers and busbars are in the high-tension room. Outside of the building there are 16 cells of aluminum lightning arresters. The choke coils are in the high-tension room.

Electrical energy from this station is carried to the Cleveland switch house on two 66,000-volt transmission lines, each line being capable of carrying the output of the station.

Development No. 2

The dam at No. 1 development has formed a lake approximately eight miles long and 2000 acres in area. Ten miles above the first development is a second of 30,000-hp. capacity. This plant differs from No. 1, which is of low head and has a large reservoir section. The reservoir at the head of No. 2 dam is only of sufficient size to equalize the flow of water for a short time. The head

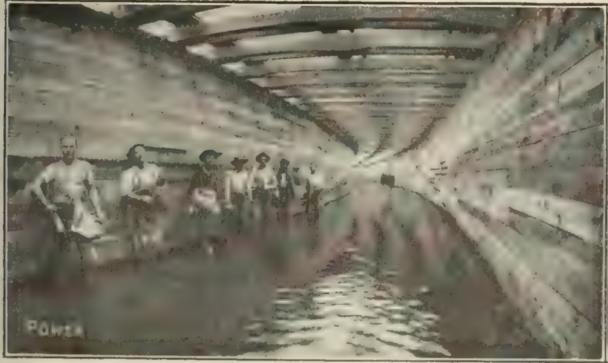


Fig. 9. Interior Construction of the Flume

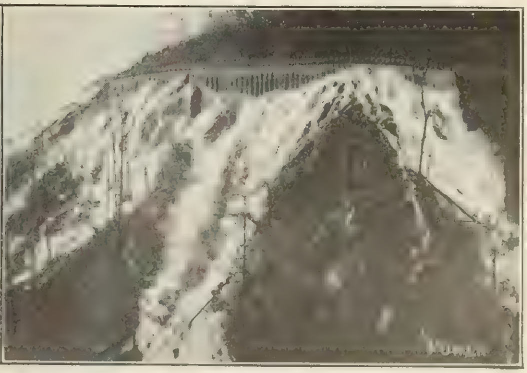


Fig. 10. Auxiliary Spillway on Mountainside

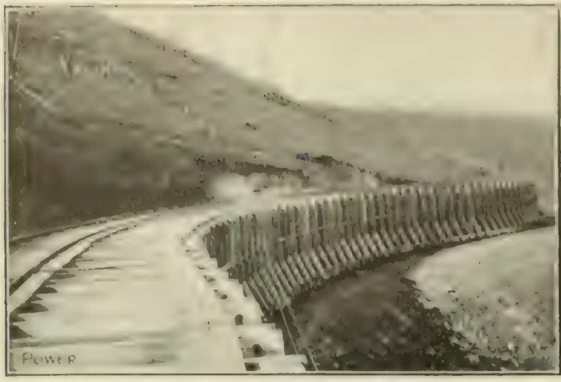


Fig. 11. Top of Flume

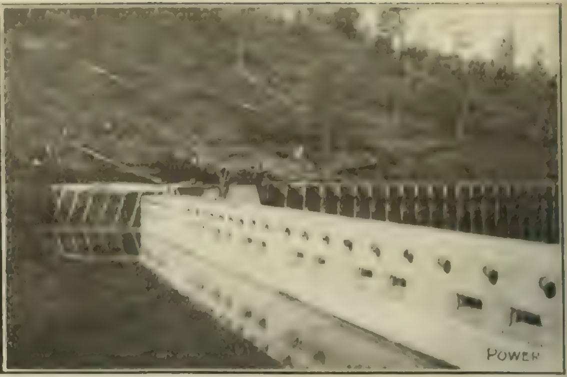


Fig. 12. Siphon Spillway Dam

available at No. 2 is 256 ft., which is obtained by a diverting dam, five miles above the station and 15 miles above No. 1 dam, and a wooden flume line through which the water flows from the dam along the mountain-side to a point above the station.

Dam No. 2, Fig. 6, is 34 ft. high and 750 ft. long. It is built of heavy timbers, forming cribs, which are filled with rocks and sheathed with heavy lumber. About 1,250,000 ft. of lumber were used. At the southern end of the dam is a large gate which controls the flow of water to the flume.

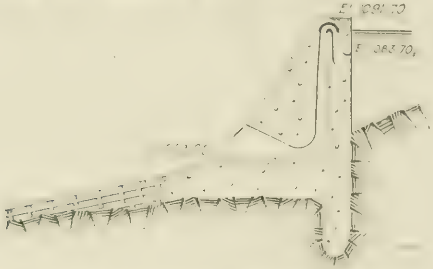


Fig. 13. Section through Siphon Spillway Dam

The Flume

The flume, a large wooden trough conveying the water from above the dam to the power house, five miles distant, is 15 ft. wide and 10 ft. high, with a carrying capacity of 550,000 gal. per min. It is supported on a shelf, Fig. 7, cut in the mountain-side. At certain points the flume is supported by viaducts, varying in height from 75 to 150 ft. and in length from 200 to 500 ft. Five of these viaducts are of steel, Fig. 8, and five are of wooden trestles supported by concrete foundations. In the construction of the flume 7,500,000 ft. of lumber were used; Fig. 9 shows the interior construction. There is an auxiliary spillway, Fig. 10, over which the water flows when the stage is high in the flume.

Fig. 11 is a near view of the flume and the top structural work. The track is used for transporting material to points along the flume. At the lower end of the flume the water is discharged into a small concrete regulating reservoir connected to the penstocks by a large section of flume. At this point the flow is regulated by a siphon spillway dam, Fig. 12, which automatically discharges excess water and keeps the flow in the penstock within certain limits. Fig. 13 is a section through the spillway dam. There are two steel penstocks, each 8 ft. in diameter, which convey the water to the turbines in the power house under a head of 256 ft. The electrically operated head gates are controlled from the power house.

No. 2 Power House

The power house, located on Caney Creek, Fig. 14, is 100 ft. long, 80 ft. wide and 55 ft. high, and is constructed of brick, concrete and steel. The power equipment at present consists of two 10,000-hp. turbines, directly connected to 7500-kw., 6600-volt, three-phase, 60-cycle generators running at 360 r.p.m. Provision has

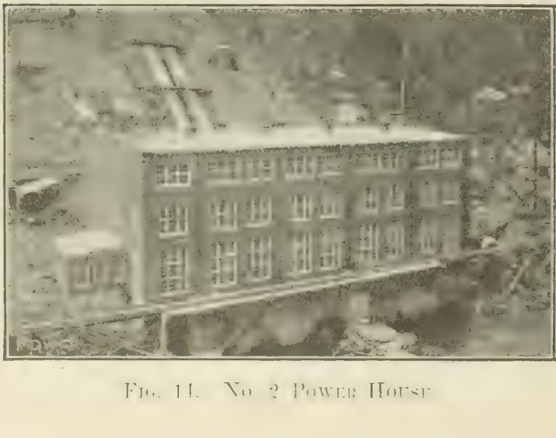


Fig. 14. No. 2 Power House

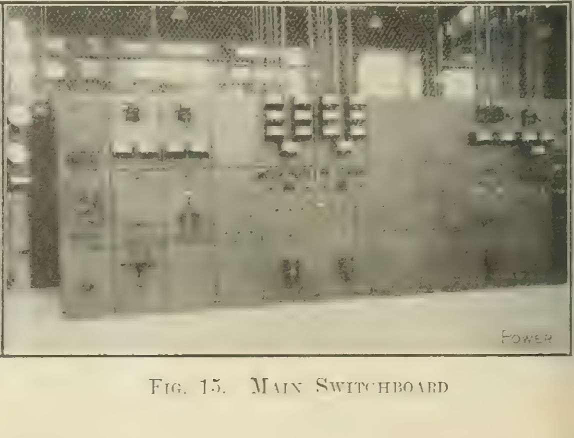


Fig. 15. Main Switchboard

been made for a third penstock and a third 10,000-hp. generating unit.

The generating units, Fig. 16, stand lengthwise of the generator room. On the same floor level are two 9375-kv.-a., three-phase, 60-cycle, 6600-120,000-volt transformers. Back of these on a concrete floor are five oil-break switches, for the machine and transformer low-tension, 6600-volt lines, and one 300-amp. oil switch for station service. There are nine oil switches in three banks, Fig. 17, delta-connected and of 120,000 volts capacity for ine control. The station transformers are on a gallery nd transform from 6600 to 110 and 220 volts. The our aluminum lightning arresters are of from 115,000 o 125,000 volts capacity. All oil switches are remotely ontrolled from a 11-panel slate switchboard, Fig. 15.

At one end of the room is a 75-hp. motor-driven, 50-w., 125-volt exciter set running at 1200 r.p.m. This nit is for emergency use, as each main generator has a 25-volt direct-current generator mounted on its shaft. n the other end of each shaft is a brake disk for bringng the rotating parts to rest after shutting off the water upply. At the other end of the generator room are two 0-hp., 900-r.p.m., motor-driven vertical sump pumps for aking care of water which finds its way to the sump rom various sources. The 4x6-in. triplex governor oil umps are belt driven from the generator shaft; the govnors are of the double-float lever type.

Nos. 1 and 2 plants will ultimately produce 55,000 hp. duplicate steel tower line connects No. 2 power house ith the Parksville plant, and from this station electrical energy is transmitted to various points over [illegible] miles of high-tension lines. The current is transmitted to the distributing station at Cleveland, 13½ miles, at 66,000 and 120,000 volts. From there the current is sent to Chattanooga, Knoxville and Rome over three-phase, 66,000-volt transmission lines, and to Nashville at 120,000 volts. All transmission lines, whether of steel tower or pole type, are of the latest design, metal crossarms being used on pole construction, and suspension-type insulators in all cases. All lines are protected from lightning by a ground wire from the top of the structures.

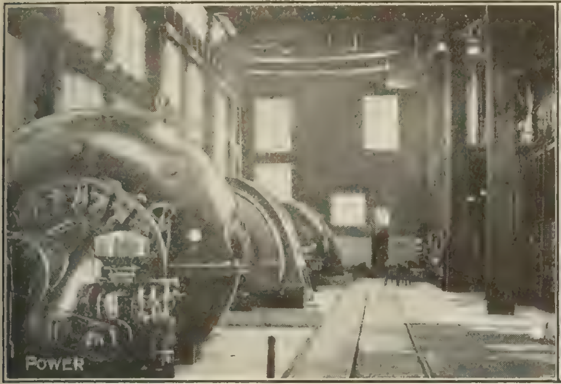


Fig. 16. Generator Units, No. 2 Power House

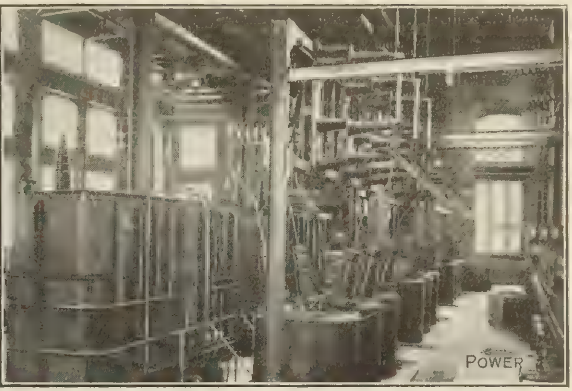


Fig. 17. Oil Switches and Transformers, No. 2 Plant

Steam Plants

The company has acquired by ownership or by contract the output of steam-power plants at Knoxville, Cleveland, Chattannooga, Rome and Nashville, as well as steam plans in smaller intervening towns along the transmission line. The steam plants are connected through substations so as to supply energy to any point on the system; they can also be run in parallel with the water-power plants and carry any proportional part of the load. The present capacity of the steam plants is 30,000 and the water power 55,000 hp. The ultimate water power that can be obtained from three other available power sites will be 115,000 hp., a total of 200,000 hp.

The cost of the two power developments on the Ocoee River was about $5,000,000. A considerable part of the electrical energy developed at these plants is used in lighting the cities along the line and for trolley-car service. The total urban population supplied numbers about 250,000.

PRINCIPAL EQUIPMENT OF THE HYDRO-ELECTRIC PLANTS OF THE TENNESSEE POWER CO.
OCOEE RIVER DEVELOPMENTS

Equipment	Kind	Size	Use	Operating Conditions	Maker
Generators	Alt. current	3750 kw	Main units	360 r.p.m., 2300 volts, three-phase, 60-cycle	Westinghouse Elec. & Mfg. Co.
Turbines	Horizontal	5000 hp	Driving main units	360 r.p.m. head 256 ft	S. Morgan, Smith Co.
Governors	Lombard		Main turbines	Oil pressure	Lombard Governor Co.
Turbines	Horizontal	250 hp	Driving exciter gen	580 r.p.m. head 256 ft	S. Morgan, Smith Co.
Generators	Direct current	120 kw	Exciters	580 r.p.m., 125 volt	Westinghouse Electric & Mfg. Co
Governors	Compensating		Exciter turbines	Oil pressure	Woodward Governor Co.
Motors	Induction	200 hp	Exciters	580 r.p.m., 2300 volt, three phase, 60 cycle	Westinghouse Elec. & Mfg. Co.
Transformers	Water cooled	3750 kv a	Line circuits	Delta and Star connected, three phase, 60 cycle	Westinghouse Elec. & Mfg. Co.
Turbines	Horizontal	10,000 hp	Driving main units	360 r.p.m., head 256 ft	I. P. Morris Co.
Generators	Alt. current	750 kw	Main units	6600 volts, three phase, 60 cycle, 360 r.p.m.	General Electric Co.
Transformers	Oil cooled	9375 kv a	Line circuits	6600—120,000 volt, three-phase, 60-cycle	General Electric Co
Motors	Induction	10 hp	Sump pumps	Intermittent, 900 r.p.m., 110 volt	Western Electric Co.
Generator	Direct current	50 kw	Exciter	Standby unit, 1200 r.p.m., 125 volt	General Electric Co
Generators	Direct current	50 kw	Exciters	Mounted on gen. shaft, 360 r.p.m., 125 volt	General Electric Co.
Motor	Induction	75 hp	Driving exciter	220 volt, 1200 r.p.m.	General Electric Co.
Governors	Lever		Main turbines	Oil pressure	I. P. Morris Co.
Pumps	Plunger	4x6"	Hydraulic governors	Belt driven	Deane Steam Pump Co.

Improvements in English Gas Producers

By Arthur H. Allen

SYNOPSIS—Special features of the Kerpely and Crossley producers tending toward efficient utilization of low-grade coals.

⁂

While the modern gas producer is in many respects efficient and satisfactory, there is scope for its improvement, especially as relates to its continuous operation, rendering it as far as possible automatic, and enabling it to deal with low-grade fuel. The following describes some recent innovations in English practice, designed to attain these ends.

KERPELY PRODUCER

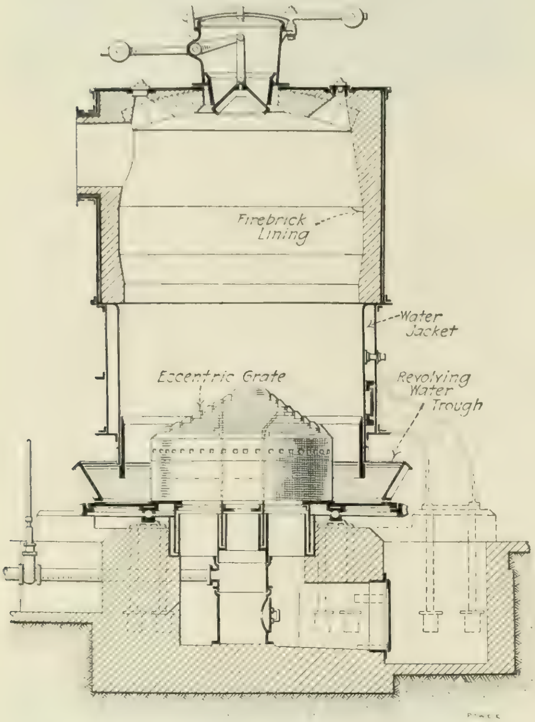


FIG. 1. KERPELY PRODUCER, SHOWING REVOLVING WATER TROUGH

The use of a water trough to seal the bottom of a pressure gas producer, while allowing the ashes to be raked out, presents no novelty; but in the Kerpely producer (Fig. 1) the water trough is made to revolve on ball bearings, so that the ashes are carried around against a fixed scraper arranged in a sloping position, which automatically conveys the ashes out of the trough and dumps them into a chute. Taking advantage of the rotary motion provided for this purpose, the inventor designed also a special grate, which is placed eccentrically on the water trough and revolves with it. The grate is elliptical in plan, and its periphery is polygonal, so that, as the grate slowly rotates, it gradually crushes the clinkers, which form at the bottom of the fire, against the apron of the water seal, breaking them up into lumps which fall into the trough and are removed as described. Special provision is also made for the separate control of the steam and air supply to the central and outer portions of the grate, so as to secure uniform combustion over the whole grate. The conical grate is flattened on the top, to keep the CO_2 zone as low as possible. The lower part of the casing consists of a water-cooled jacket, to which the clinker cannot cling as it does to a brick lining. The grate revolves slowly and requires only one or two horsepower to drive it.

Owing to the ability of this producer to gasify coal more rapidly than the ordinary type, a smaller plant suffices to do the same work; the automatic removal of the ashes and the self-clinkering action of the grate reduce labor costs; repairs are also eliminated, and gas of good quality can be obtained from fuel containing as much as 35 per cent. of ash. The gas is also of very uniform composition, owing to the steady and continuous operation of the producer. In the course of a test of one of these plants, at Vienna, gasifying coke breeze, the net efficiency of the producer was found to be 89.8 per cent., 75.37 per cent. of the heat energy of the fuel being made available in the form of gas and 14.43 per cent. being used for the production of steam.

E. G. Appleby & Co., the British agents for the Kerpely producer, have devised a poke hole for use on any pressure producer, which can be opened without allowing gas to escape or air to enter. The hole is provided with compressed-air jets, which are adjusted so as to secure equilibrium between the gas pressure and that of the jets. Thus no gas is lost, and the attendants are able to work without inconvenience from inhalation of the poisonous gas. A still better plan which they have devised is a system of automatic stirring applied to the top of the producer, as shown in Fig. 2. The curved pokers, of different lengths, are provided with pinions gearing with a circular rack, and are carried in a frame attached to the hopper. The top section of the producer is slowly rotated by worm gearing, causing the pokers to travel around the fuel bed, and also rotating on their own axes, so that the upper layers of the fuel are thoroughly stirred, and holes are prevented.

CROSSLEY SUCTION PRODUCER

In the new producer brought out by Messrs. Crossley Bros. last summer, the difficulties met with in gasifying low-grade fuel are overcome in a totally different manner. As shown in Fig. 3, poke holes *F* are provided in the top of the producer, through which the poker can be introduced in a line parallel to the brickwork and close to it, so that clinker which adheres to the firebrick lining can be loosened without fear of striking the brick, and therefore with the minimum risk of damaging the lining. The fire grate is quite open to the atmosphere, and is composed of a number of stepped plates, of such a diameter and so supported on legs as to stand outside the natural angle of repose of the fuel. Thus the center of the column of fuel rests upon its own bed of ash, and the bottom of the fire is in full view of the attendant, who can clean every part of the grate and remove clinker and ash, without interfering with the operation of the producer. In the new Crossley type the vaporizer is entirely separate from the producer, simplifying the construction and operation of the producer, and facilitating repairs. It will be seen from the sectional elevation that the construction of the generator is extremely simple, consisting of little more than a casing lined with firebrick.

The vaporizer consists of a cast-iron box *G* through which the hot gas passes on its way to the scrubber, with a water seal at the bottom. The box contains a number of gilled tubes *J*, with internal tubes arranged on the "Field tube" principle, being supported only from the top, so that they are free to expand and contract without risk of breaking joints. Water is led through the internal tube to the bottom of the first gilled tube in which it rises, and overflows at *L* into the internal tube of the next element, passing through all the elements in series; in the last tube *M* it is wholly converted into steam, which is led off to the grate and fed into the fire through a perforated ring *O*. It will be noticed that the water in the tubes is surrounded with a jacket of hot gas, and the vaporizer both cools the gas and raises steam. At the outlet from the vaporizer the gas passes through two cascades of water *P* from the overflow of the scrubber, by which means the heavier impurities are washed out of the gas, and the work required of the scrubber is lessened. From the scrubber the gas is led away to the engine. An induction fan is used instead of a blower for starting the producer, and is placed as close to the engine as possible. This has the advantages that the producer is started as a suction plant instead of under pressure, so that there is no risk of escape of gas; the pipe to the engine is filled with gas, and one man can easily start both the producer and the engine.

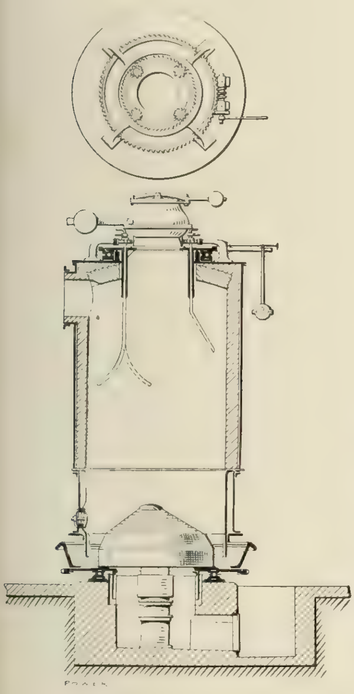


FIG. 2. KERPELY PRODUCER WITH ROTARY POKERS

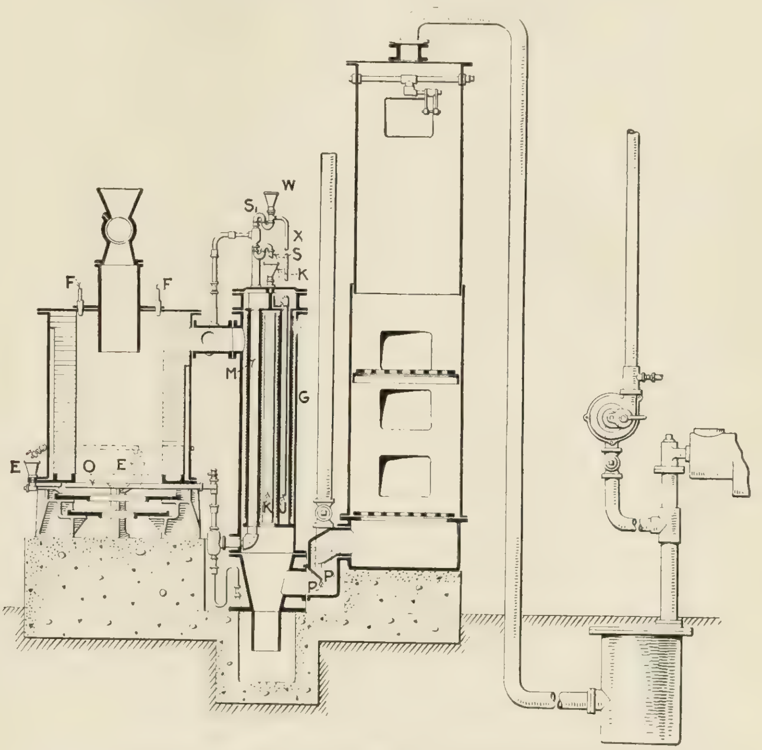


FIG. 3. SECTION OF CROSSLEY OPEN-HEARTH SUCTION PRODUCER

An ingenious automatic device is employed to feed water into the vaporizer at the correct rate, to suit the load on the engine. Water is allowed to trickle into the funnel *W*, and when the plant is idle, it is caused by the siphon bend S_1 to escape by the overflow pipe *X*; but when there is a load on the engine, the suction in the gas outlet draws water over the top of the bend S_1, whence it falls into the lower bend *S*, and thence flows into the funnel *K* on the vaporizer. The greater the load on the engine the more rapidly is the water drawn over and fed to the vaporizer, and when once the correct rate of flow has been ascertained, the adjustment is automatic for all loads. Provision is made to allow water to trickle on the grate through the funnels *EE* when starting the producer, so that there is no delay while steam is being raised in the vaporizer. There are no moving parts in the automatic water regulator.

MOORE PRODUCER

The Moore producer differs from the foregoing in that it is designed for byproduct recovery, even in plants having an output as small as 300 hp. For this purpose it is necessary to keep down the temperature of the gas, lest

Working Up a Boiler Test

Equivalent Evaporation From and at 212 Degrees

Temperature of Feed Water Degrees Fahrenheit	Pressure of Steam in Pounds Absolute—Dry Saturated												Temperature of Feed Water Degrees Fahrenheit
	15	25	35	45	55	65	75	85	95	105	115	125	
32	1.1858	1.1958	1.2024	1.2073	1.2113	1.2144	1.2171	1.2195	1.2216	1.2234	1.2251	1.2266	32
35	1.1827	1.1927	1.1993	1.2042	1.2081	1.2113	1.2140	1.2164	1.2184	1.2203	1.2219	1.2235	35
40	1.1775	1.1875	1.1941	1.1990	1.2030	1.2062	1.2088	1.2112	1.2133	1.2151	1.2168	1.2183	40
45	1.1723	1.1823	1.1889	1.1939	1.1978	1.2010	1.2037	1.2060	1.2081	1.2099	1.2116	1.2131	45
50	1.1672	1.1772	1.1838	1.1887	1.1926	1.1958	1.1985	1.2009	1.2029	1.2048	1.2064	1.2080	50
55	1.1620	1.1720	1.1786	1.1836	1.1875	1.1907	1.1933	1.1957	1.1978	1.1996	1.2013	1.2028	55
60	1.1569	1.1669	1.1735	1.1784	1.1823	1.1855	1.1882	1.1906	1.1926	1.1945	1.1961	1.1977	60
65	1.1517	1.1617	1.1683	1.1733	1.1772	1.1804	1.1830	1.1854	1.1875	1.1893	1.1910	1.1925	65
70	1.1466	1.1566	1.1632	1.1681	1.1720	1.1752	1.1779	1.1803	1.1823	1.1842	1.1858	1.1874	70
75	1.1414	1.1514	1.1580	1.1630	1.1669	1.1701	1.1728	1.1751	1.1772	1.1790	1.1807	1.1823	75
80	1.1363	1.1463	1.1529	1.1578	1.1618	1.1650	1.1676	1.1700	1.1721	1.1739	1.1756	1.1771	80
85	1.1312	1.1412	1.1478	1.1527	1.1566	1.1598	1.1625	1.1649	1.1669	1.1688	1.1704	1.1720	85
90	1.1260	1.1360	1.1426	1.1476	1.1515	1.1547	1.1574	1.1597	1.1618	1.1636	1.1653	1.1668	90
95	1.1209	1.1309	1.1375	1.1424	1.1463	1.1495	1.1522	1.1546	1.1566	1.1585	1.1602	1.1617	95
100	1.1158	1.1258	1.1323	1.1373	1.1412	1.1444	1.1471	1.1495	1.1515	1.1534	1.1550	1.1566	100
105	1.1106	1.1206	1.1272	1.1322	1.1361	1.1393	1.1420	1.1443	1.1464	1.1482	1.1499	1.1516	105
110	1.1055	1.1155	1.1221	1.1270	1.1309	1.1341	1.1368	1.1392	1.1412	1.1431	1.1447	1.1463	110
115	1.1004	1.1103	1.1169	1.1219	1.1258	1.1290	1.1248	1.1341	1.1361	1.1380	1.1396	1.1412	115
120	1.0952	1.1052	1.1118	1.1167	1.1207	1.1239	1.1265	1.1289	1.1310	1.1328	1.1345	1.1360	120
125	1.0901	1.1001	1.1067	1.1116	1.1155	1.1187	1.1214	1.1238	1.1258	1.1277	1.1293	1.1309	125
130	1.0849	1.0949	1.1015	1.1065	1.1104	1.1136	1.1163	1.1186	1.1207	1.1225	1.1242	1.1257	130
135	1.0798	1.0898	1.0964	1.1013	1.1052	1.1084	1.1111	1.1135	1.1155	1.1174	1.1190	1.1206	135
140	1.0746	1.0846	1.0912	1.0962	1.1001	1.1033	1.1060	1.1083	1.1104	1.1123	1.1139	1.1154	140
145	1.0695	1.0795	1.0861	1.0910	1.0950	1.0981	1.1008	1.1032	1.1053	1.1071	1.1088	1.1103	145
150	1.0643	1.0743	1.0809	1.0859	1.0898	1.0930	1.0957	1.0981	1.1001	1.1020	1.1036	1.1052	150
155	1.0592	1.0692	1.0758	1.0807	1.0846	1.0878	1.0905	1.0929	1.0950	1.0968	1.0985	1.1000	155
160	1.0540	1.0640	1.0706	1.0756	1.0795	1.0827	1.0854	1.0877	1.0898	1.0917	1.0933	1.0948	160
165	1.0489	1.0589	1.0655	1.0704	1.0743	1.0775	1.0802	1.0826	1.0846	1.0865	1.0881	1.0897	165
170	1.0437	1.0537	1.0603	1.0653	1.0692	1.0724	1.0751	1.0774	1.0795	1.0813	1.0830	1.0845	170
171	1.0427	1.0527	1.0593	1.0642	1.0681	1.0713	1.0740	1.0764	1.0785	1.0803	1.0820	1.0835	171
172	1.0417	1.0517	1.0583	1.0632	1.0671	1.0703	1.0730	1.0754	1.0774	1.0793	1.0809	1.0825	172
173	1.0406	1.0506	1.0572	1.0622	1.0661	1.0693	1.0720	1.0743	1.0764	1.0782	1.0799	1.0814	173
174	1.0396	1.0496	1.0562	1.0611	1.0651	1.0683	1.0709	1.0733	1.0754	1.0772	1.0789	1.0804	174
175	1.0386	1.0486	1.0552	1.0601	1.0640	1.0672	1.0699	1.0723	1.0743	1.0762	1.0778	1.0793	175
176	1.0375	1.0475	1.0541	1.0591	1.0630	1.0662	1.0689	1.0712	1.0733	1.0752	1.0768	1.0783	176
177	1.0365	1.0465	1.0531	1.0580	1.0620	1.0651	1.0678	1.0702	1.0723	1.0741	1.0758	1.0773	177
178	1.0355	1.0455	1.0521	1.0570	1.0609	1.0641	1.0668	1.0692	1.0712	1.0731	1.0747	1.0763	178
179	1.0344	1.0444	1.0510	1.0560	1.0599	1.0631	1.0658	1.0681	1.0702	1.0721	1.0737	1.0752	179
180	1.0334	1.0434	1.0500	1.0549	1.0589	1.0621	1.0647	1.0671	1.0692	1.0710	1.0727	1.0742	180
181	1.0324	1.0424	1.0490	1.0539	1.0578	1.0610	1.0637	1.0661	1.0681	1.0700	1.0716	1.0732	181
182	1.0313	1.0413	1.0479	1.0529	1.0568	1.0600	1.0627	1.0650	1.0671	1.0690	1.0706	1.0721	182
183	1.0303	1.0403	1.0469	1.0518	1.0558	1.0590	1.0616	1.0640	1.0661	1.0679	1.0696	1.0711	183
184	1.0293	1.0393	1.0459	1.0508	1.0547	1.0579	1.0606	1.0630	1.0650	1.0669	1.0685	1.0701	184
185	1.0282	1.0382	1.0448	1.0498	1.0537	1.0569	1.0596	1.0619	1.0640	1.0659	1.0675	1.0691	185
186	1.0272	1.0372	1.0438	1.0488	1.0527	1.0559	1.0585	1.0609	1.0630	1.0648	1.0665	1.0680	186
187	1.0262	1.0362	1.0428	1.0477	1.0516	1.0548	1.0575	1.0599	1.0619	1.0638	1.0654	1.0670	187
188	1.0251	1.0351	1.0417	1.0467	1.0506	1.0538	1.0565	1.0588	1.0609	1.0628	1.0644	1.0660	188
189	1.0241	1.0341	1.0407	1.0457	1.0496	1.0528	1.0554	1.0578	1.0599	1.0617	1.0634	1.0649	189
190	1.0231	1.0331	1.0397	1.0446	1.0485	1.0517	1.0544	1.0568	1.0588	1.0607	1.0623	1.0639	190
191	1.0220	1.0320	1.0386	1.0436	1.0475	1.0507	1.0534	1.0557	1.0578	1.0597	1.0613	1.0629	191
192	1.0210	1.0310	1.0376	1.0425	1.0465	1.0497	1.0523	1.0547	1.0568	1.0586	1.0603	1.0618	192
193	1.0200	1.0300	1.0366	1.0415	1.0454	1.0486	1.0513	1.0537	1.0557	1.0576	1.0592	1.0608	193
194	1.0189	1.0289	1.0355	1.0405	1.0444	1.0476	1.0503	1.0526	1.0547	1.0566	1.0582	1.0597	194
195	1.0179	1.0279	1.0345	1.0394	1.0434	1.0466	1.0492	1.0516	1.0537	1.0555	1.0572	1.0587	195
196	1.0169	1.0269	1.0335	1.0384	1.0423	1.0455	1.0482	1.0506	1.0526	1.0545	1.0561	1.0577	196
197	1.0158	1.0258	1.0324	1.0374	1.0413	1.0445	1.0472	1.0495	1.0516	1.0535	1.0551	1.0566	197
198	1.0148	1.0248	1.0314	1.0363	1.0403	1.0435	1.0461	1.0485	1.0506	1.0524	1.0541	1.0556	198
199	1.0138	1.0238	1.0304	1.0353	1.0392	1.0424	1.0451	1.0475	1.0495	1.0514	1.0530	1.0546	199
200	1.0127	1.0227	1.0293	1.0343	1.0382	1.0414	1.0441	1.0464	1.0485	1.0504	1.0520	1.0535	200
201	1.0117	1.0217	1.0283	1.0332	1.0372	1.0404	1.0430	1.0454	1.0475	1.0493	1.0510	1.0525	201
202	1.0107	1.0207	1.0273	1.0322	1.0361	1.0393	1.0420	1.0444	1.0464	1.0483	1.0499	1.0515	202
203	1.0096	1.0196	1.0262	1.0312	1.0351	1.0383	1.0410	1.0433	1.0454	1.0472	1.0489	1.0504	203
204	1.0086	1.0186	1.0252	1.0301	1.0340	1.0372	1.0399	1.0423	1.0444	1.0462	1.0479	1.0494	204
205	1.0076	1.0176	1.0242	1.0291	1.0330	1.0362	1.0389	1.0413	1.0433	1.0452	1.0468	1.0484	205
206	1.0065	1.0165	1.0231	1.0281	1.0320	1.0352	1.0379	1.0402	1.0423	1.0441	1.0458	1.0473	206
207	1.0055	1.0155	1.0221	1.0270	1.0309	1.0341	1.0368	1.0392	1.0413	1.0431	1.0448	1.0463	207
208	1.0045	1.0144	1.0210	1.0260	1.0299	1.0331	1.0358	1.0381	1.0402	1.0421	1.0437	1.0453	208
209	1.0034	1.0134	1.0200	1.0250	1.0289	1.0321	1.0347	1.0371	1.0392	1.0410	1.0427	1.0442	209
210	1.0024	1.0124	1.0190	1.0239	1.0278	1.0310	1.0337	1.0361	1.0381	1.0400	1.0416	1.0432	210
212	1.0003	1.0103	1.0169	1.0218	1.0258	1.0290	1.0316	1.0340	1.0361	1.0379	1.0396	1.0411	212
215	0.9972	1.0072	1.0138	1.0188	1.0227	1.0259	1.0285	1.0309	1.0330	1.0348	1.0365	1.0380	215
220	0.9920	1.0020	1.0086	1.0135	1.0174	1.0206	1.0233	1.0257	1.0277	1.0296	1.0312	1.0328	220
225	0.9868	0.9968	1.0034	1.0083	1.0123	1.0155	1.0181	1.0205	1.0226	1.0244	1.0261	1.0276	225
230	0.9816	0.9916	0.9981	1.0031	1.0070	1.0102	1.0129	1.0153	1.0173	1.0192	1.0208	1.0224	230
235	0.9764	0.9864	0.9930	0.9979	1.0019	1.0050	1.0077	1.0101	1.0122	1.0140	1.0157	1.0172	235
240	0.9711	0.9811	0.9877	0.9927	0.9966	0.9998	1.0025	1.0048	1.0069	1.0088	1.0104	1.0120	240
245	0.9660	0.9759	0.9825	0.9874	0.9913	0.9945	0.9972	0.9996	1.0016	1.0035	1.0052	1.0067	245
250	0.9606	0.9706	0.9772	0.9822	0.9861	0.9893	0.9920	0.9943	0.9964	0.9982	0.9999	1.0014	250
255	0.9555	0.9655	0.9721	0.9770	0.9809	0.9841	0.9868	0.9892	0.9912	0.9931	0.9947	0.9963	255
260	0.9502	0.9602	0.9668	0.9718	0.9757	0.9789	0.9816	0.9839	0.9860	0.9878	0.9895	0.9910	260
265	0.9450	0.9550	0.9616	0.9665	0.9704	0.9736	0.9763	0.9787	0.9807	0.9826	0.9842	0.9858	265
270	0.9397	0.9497	0.9563	0.9613	0.9652	0.9684	0.9710	0.9734	0.9755	0.9773	0.9790	0.9805	270
275	0.9345	0.9446	0.9511	0.9560	0.9599	0.9631	0.9658	0.9682	0.9702	0.9721	0.9737	0.9754	275
280	0.9292	0.9392	0.9458	0.9507	0.9547	0.9579	0.9605	0.9629	0.9650	0.9668	0.9685	0.9700	280
285	0.9238	0.9338	0.9404	0.9454	0.9493	0.9525	0.9552	0.9575	0.9596	0.9615	0.9631	0.9647	285
290	0.9186	0.9286	0.9352	0.9401	0.9440	0.9472	0.9499	0.9523	0.9543	0.9562	0.9579	0.9594	290
295	0.9133	0.9233	0.9299	0.9349	0.9388	0.9420	0.9447	0.9470	0.9491	0.9509	0.9526	0.9541	295
300	0.9080	0.9180	0.9246	0.9295	0.9334	0.9366	0.9393	0.9417	0.9437	0.9456	0.9472	0.9488	300

Equivalent Evaporation From and at 212 Degrees--Continued

Temperature of Feed Water Degrees Fahrenheit	Pressure of Steam in Pounds Absolute—Dry Saturated												Temperature of Feed Water Degrees Fahrenheit
	135	145	155	165	175	185	195	205	215	225	235	245	
32	1.2279	1.2292	1.2304	1.2315	1.2324	1.2333	1.2342	1.2351	1.2357	1.2365	1.2372	1.2378	32
35	1.2248	1.2261	1.2273	1.2283	1.2293	1.2302	1.2311	1.2319	1.2326	1.2334	1.2341	1.2347	35
40	1.2196	1.2209	1.2221	1.2232	1.2241	1.2250	1.2259	1.2268	1.2274	1.2282	1.2289	1.2295	40
45	1.2144	1.2157	1.2170	1.2180	1.2189	1.2198	1.2208	1.2216	1.2222	1.2230	1.2238	1.2244	45
50	1.2093	1.2106	1.2118	1.2128	1.2137	1.2147	1.2156	1.2164	1.2170	1.2179	1.2186	1.2192	50
55	1.2042	1.2054	1.2066	1.2077	1.2086	1.2095	1.2104	1.2113	1.2119	1.2127	1.2134	1.2141	55
60	1.1990	1.2002	1.2015	1.2025	1.2034	1.2044	1.2053	1.2061	1.2067	1.2076	1.2083	1.2089	60
65	1.1939	1.1951	1.1963	1.1974	1.1983	1.1992	1.2002	1.2010	1.2016	1.2021	1.2031	1.2038	65
70	1.1887	1.1900	1.1912	1.1922	1.1932	1.1941	1.1950	1.1958	1.1965	1.1973	1.1980	1.1986	70
75	1.1836	1.1848	1.1861	1.1871	1.1880	1.1889	1.1899	1.1907	1.1913	1.1921	1.1929	1.1935	75
80	1.1785	1.1797	1.1809	1.1820	1.1829	1.1838	1.1847	1.1856	1.1862	1.1870	1.1877	1.1883	80
85	1.1733	1.1745	1.1758	1.1768	1.1777	1.1787	1.1796	1.1804	1.1810	1.1819	1.1826	1.1832	85
90	1.1682	1.1694	1.1707	1.1717	1.1726	1.1735	1.1745	1.1753	1.1759	1.1767	1.1775	1.1781	90
95	1.1630	1.1643	1.1655	1.1665	1.1675	1.1684	1.1693	1.1701	1.1708	1.1716	1.1723	1.1729	95
100	1.1579	1.1591	1.1604	1.1614	1.1623	1.1633	1.1642	1.1650	1.1657	1.1665	1.1672	1.1678	100
105	1.1528	1.1540	1.1552	1.1563	1.1572	1.1581	1.1591	1.1599	1.1606	1.1613	1.1620	1.1627	105
110	1.1476	1.1489	1.1501	1.1511	1.1521	1.1530	1.1539	1.1547	1.1553	1.1562	1.1569	1.1575	110
115	1.1425	1.1437	1.1450	1.1460	1.1469	1.1479	1.1488	1.1496	1.1503	1.1511	1.1518	1.1524	115
120	1.1374	1.1386	1.1398	1.1409	1.1418	1.1427	1.1436	1.1445	1.1452	1.1459	1.1466	1.1472	120
125	1.1322	1.1335	1.1347	1.1357	1.1366	1.1376	1.1385	1.1393	1.1400	1.1408	1.1415	1.1421	125
130	1.1271	1.1283	1.1295	1.1306	1.1315	1.1324	1.1334	1.1342	1.1349	1.1356	1.1363	1.1370	130
135	1.1219	1.1232	1.1244	1.1254	1.1264	1.1273	1.1282	1.1290	1.1298	1.1305	1.1312	1.1318	135
140	1.1168	1.1180	1.1193	1.1203	1.1212	1.1221	1.1231	1.1239	1.1246	1.1253	1.1261	1.1267	140
145	1.1116	1.1129	1.1141	1.1151	1.1161	1.1170	1.1179	1.1188	1.1195	1.1202	1.1209	1.1215	145
150	1.1065	1.1077	1.1090	1.1100	1.1109	1.1119	1.1128	1.1136	1.1143	1.1150	1.1158	1.1164	150
155	1.1013	1.1026	1.1038	1.1048	1.1058	1.1067	1.1076	1.1085	1.1092	1.1099	1.1106	1.1112	155
160	1.0962	1.0974	1.0987	1.0997	1.1006	1.1015	1.1025	1.1033	1.1040	1.1047	1.1055	1.1061	160
165	1.0910	1.0923	1.0935	1.0945	1.0955	1.0964	1.0973	1.0981	1.0989	1.0996	1.1003	1.1009	165
170	1.0859	1.0871	1.0883	1.0894	1.0903	1.0912	1.0922	1.0930	1.0937	1.0944	1.0951	1.0958	170
171	1.0848	1.0861	1.0873	1.0883	1.0893	1.0902	1.0911	1.0920	1.0927	1.0934	1.0941	1.0947	171
172	1.0838	1.0850	1.0863	1.0873	1.0882	1.0892	1.0901	1.0909	1.0916	1.0924	1.0931	1.0937	172
173	1.0828	1.0840	1.0853	1.0863	1.0872	1.0881	1.0891	1.0899	1.0906	1.0913	1.0921	1.0927	173
174	1.0817	1.0830	1.0842	1.0853	1.0862	1.0871	1.0880	1.0889	1.0896	1.0903	1.0910	1.0916	174
175	1.0807	1.0820	1.0832	1.0842	1.0852	1.0861	1.0870	1.0878	1.0886	1.0893	1.0900	1.0906	175
176	1.0797	1.0809	1.0822	1.0832	1.0841	1.0850	1.0860	1.0868	1.0875	1.0882	1.0890	1.0896	176
177	1.0786	1.0799	1.0811	1.0822	1.0831	1.0840	1.0849	1.0858	1.0865	1.0872	1.0879	1.0885	177
178	1.0776	1.0789	1.0801	1.0811	1.0820	1.0830	1.0839	1.0847	1.0854	1.0862	1.0869	1.0875	178
179	1.0766	1.0778	1.0791	1.0801	1.0810	1.0819	1.0829	1.0837	1.0844	1.0851	1.0859	1.0865	179
180	1.0756	1.0768	1.0780	1.0791	1.0800	1.0809	1.0818	1.0827	1.0834	1.0841	1.0848	1.0854	180
181	1.0745	1.0758	1.0770	1.0780	1.0790	1.0799	1.0808	1.0816	1.0824	1.0831	1.0838	1.0844	181
182	1.0735	1.0747	1.0760	1.0770	1.0779	1.0788	1.0798	1.0806	1.0813	1.0820	1.0828	1.0834	182
183	1.0725	1.0737	1.0749	1.0760	1.0769	1.0778	1.0787	1.0796	1.0803	1.0810	1.0817	1.0823	183
184	1.0714	1.0727	1.0739	1.0749	1.0759	1.0768	1.0777	1.0785	1.0793	1.0800	1.0807	1.0813	184
185	1.0704	1.0716	1.0729	1.0739	1.0748	1.0758	1.0767	1.0775	1.0782	1.0789	1.0797	1.0803	185
186	1.0694	1.0706	1.0718	1.0729	1.0738	1.0747	1.0756	1.0765	1.0772	1.0779	1.0786	1.0793	186
187	1.0683	1.0696	1.0708	1.0718	1.0728	1.0737	1.0746	1.0754	1.0762	1.0769	1.0776	1.0782	187
188	1.0673	1.0685	1.0698	1.0708	1.0717	1.0727	1.0736	1.0744	1.0751	1.0758	1.0766	1.0772	188
189	1.0663	1.0675	1.0687	1.0698	1.0707	1.0716	1.0725	1.0734	1.0741	1.0748	1.0755	1.0762	189
190	1.0652	1.0665	1.0677	1.0687	1.0697	1.0706	1.0715	1.0723	1.0731	1.0738	1.0745	1.0751	190
191	1.0642	1.0654	1.0667	1.0677	1.0686	1.0695	1.0705	1.0713	1.0720	1.0727	1.0735	1.0741	191
192	1.0632	1.0644	1.0656	1.0667	1.0676	1.0685	1.0694	1.0703	1.0710	1.0717	1.0724	1.0731	192
193	1.0621	1.0634	1.0646	1.0656	1.0666	1.0675	1.0684	1.0692	1.0700	1.0707	1.0714	1.0720	193
194	1.0611	1.0623	1.0636	1.0646	1.0655	1.0664	1.0674	1.0682	1.0689	1.0696	1.0704	1.0710	194
195	1.0601	1.0613	1.0625	1.0636	1.0645	1.0654	1.0663	1.0672	1.0679	1.0686	1.0693	1.0700	195
196	1.0590	1.0603	1.0615	1.0625	1.0635	1.0644	1.0653	1.0661	1.0669	1.0676	1.0683	1.0689	196
197	1.0580	1.0592	1.0605	1.0615	1.0624	1.0633	1.0643	1.0651	1.0658	1.0665	1.0673	1.0679	197
198	1.0570	1.0582	1.0594	1.0605	1.0614	1.0623	1.0632	1.0641	1.0648	1.0655	1.0662	1.0668	198
199	1.0559	1.0572	1.0584	1.0594	1.0603	1.0613	1.0622	1.0630	1.0637	1.0645	1.0652	1.0658	199
200	1.0549	1.0561	1.0574	1.0584	1.0593	1.0602	1.0612	1.0620	1.0627	1.0634	1.0642	1.0648	200
201	1.0539	1.0551	1.0563	1.0574	1.0584	1.0592	1.0601	1.0610	1.0617	1.0624	1.0631	1.0637	201
202	1.0528	1.0541	1.0553	1.0563	1.0572	1.0582	1.0591	1.0599	1.0606	1.0614	1.0621	1.0627	202
203	1.0518	1.0530	1.0543	1.0553	1.0562	1.0571	1.0581	1.0589	1.0596	1.0603	1.0611	1.0617	203
204	1.0507	1.0520	1.0532	1.0542	1.0552	1.0561	1.0570	1.0579	1.0586	1.0593	1.0600	1.0606	204
205	1.0497	1.0509	1.0522	1.0532	1.0541	1.0551	1.0560	1.0568	1.0575	1.0583	1.0590	1.0596	205
206	1.0487	1.0499	1.0511	1.0522	1.0531	1.0540	1.0550	1.0558	1.0565	1.0572	1.0579	1.0586	206
207	1.0476	1.0489	1.0501	1.0511	1.0521	1.0530	1.0539	1.0548	1.0555	1.0562	1.0569	1.0575	207
208	1.0466	1.0478	1.0491	1.0501	1.0510	1.0520	1.0529	1.0537	1.0544	1.0552	1.0559	1.0565	208
209	1.0456	1.0468	1.0480	1.0491	1.0500	1.0509	1.0519	1.0527	1.0534	1.0541	1.0548	1.0555	209
210	1.0445	1.0458	1.0470	1.0480	1.0490	1.0499	1.0508	1.0516	1.0524	1.0531	1.0538	1.0544	210
212	1.0425	1.0437	1.0449	1.0460	1.0469	1.0478	1.0487	1.0496	1.0503	1.0510	1.0517	1.0523	212
215	1.0394	1.0406	1.0418	1.0429	1.0438	1.0447	1.0457	1.0465	1.0472	1.0479	1.0486	1.0493	215
220	1.0341	1.0353	1.0366	1.0376	1.0385	1.0395	1.0404	1.0412	1.0419	1.0427	1.0434	1.0440	220
225	1.0290	1.0302	1.0314	1.0325	1.0334	1.0343	1.0352	1.0361	1.0368	1.0375	1.0382	1.0388	225
230	1.0237	1.0249	1.0262	1.0272	1.0281	1.0291	1.0300	1.0308	1.0315	1.0323	1.0330	1.0336	230
235	1.0185	1.0198	1.0210	1.0221	1.0230	1.0239	1.0248	1.0257	1.0264	1.0271	1.0278	1.0284	235
240	1.0133	1.0145	1.0158	1.0168	1.0177	1.0187	1.0196	1.0204	1.0211	1.0218	1.0226	1.0232	240
245	1.0080	1.0093	1.0105	1.0115	1.0125	1.0134	1.0143	1.0151	1.0159	1.0166	1.0173	1.0179	245
250	1.0028	1.0040	1.0053	1.0063	1.0072	1.0081	1.0091	1.0099	1.0166	1.0113	1.0121	1.0127	250
255	0.9976	0.9989	1.0001	1.0011	1.0021	1.0030	1.0039	1.0047	1.0055	1.0062	1.0069	1.0075	255
260	0.9924	0.9936	0.9948	0.9959	0.9968	0.9977	0.9987	0.9995	1.0002	1.0009	1.0016	1.0023	260
265	0.9871	0.9884	0.9896	0.9906	0.9915	0.9925	0.9934	0.9942	0.9950	0.9957	0.9964	0.9970	265
270	0.9819	0.9831	0.9843	0.9854	0.9863	0.9872	0.9881	0.9890	0.9897	0.9904	0.9911	0.9918	270
275	0.9766	0.9778	0.9791	0.9801	0.9810	0.9820	0.9829	0.9837	0.9844	0.9852	0.9859	0.9865	275
280	0.9714	0.9726	0.9738	0.9749	0.9758	0.9767	0.9776	0.9785	0.9792	0.9799	0.9806	0.9812	280
285	0.9660	0.9672	0.9685	0.9695	0.9704	0.9714	0.9723	0.9731	0.9738	0.9745	0.9753	0.9759	285
290	0.9607	0.9620	0.9632	0.9642	0.9652	0.9661	0.9670	0.9678	0.9686	0.9693	0.9700	0.9706	290
295	0.9555	0.9567	0.9580	0.9590	0.9599	0.9608	0.9618	0.9626	0.9633	0.9640	0.9648	0.9654	295
300	0.9501	0.9514	0.9526	0.9536	0.9546	0.9555	0.9564	0.9572	0.9580	0.9587	0.9594	0.9600	300

nearly five and one-half times as much heat would be required to boil it away. If the flask absorbed heat at the same rate all the time it would take over five times as long to make the water into steam after it began to boil as to heat it to the boiling point. This evaporation is taking place "from and at 212 deg.," i.e., from feed water of 212 deg. temperature into steam of 212 deg. temperature and 14.7 lb. pressure, and this evaporation from and at 212 deg. requiring 970.4 B.t.u. per lb. is the standard to which evaporations from other temperatures of feed and at other pressure are referred for comparison.

We have seen above that it takes 1027.88 B.t.u. to make a pound of steam under the conditions of the supposed test. Then each pound of steam made under these conditions takes

$$1027.88 \div 970.4 = 1.0592$$

times as much heat as it does to make a pound of steam "from and at 212 deg." This figure 1.0592 is called the "factor of evaporation" for the given condition. Tables of them are to be found in most engineers' reference books. The accompanying table is reproduced from Power of May 10, 1910, at which time it was calculated for the then new values of the Marks-Davis tables. The factors are found by dividing the difference between the total heat H of the steam at the given pressure and the heat of the liquid h at the feed-water temperature, by 970.4.

$$\textit{factor of evaporation} = \frac{H - h}{970.4}$$

We have found above that the boiler under test evaporated 13,282.453 lb. of water per hour from 196 deg. and at 122.6 lb. This would be equivalent to

$$13{,}282.453 \times 1.0592 = 14{,}068.774 \textit{ lb.}$$

from and at 212 deg.

The evaporation of 34.5 lb. per hour from and at 212 deg. is the requirement per boiler horsepower. The horsepower developed by the boiler on test was therefore

$$\frac{14{,}068.774}{34.5} = 407.79 \textit{ boiler horsepower}$$

This boiler horsepower corresponds to the absorption of 33,478.8 B.t.u. per hour. The horsepower could be found then by multiplying the evaporation in pounds per hour by the British thermal units required per pound evaporated, and dividing the number of British thermal units absorbed per hour thus found by 33,478.8 thus:

$$\frac{13{,}282.453 \times 1027.88}{33{,}478.8} = 407.8 \textit{ boiler horsepower}$$

The fundamental basis for the horsepower is that adopted by the Committee on Boiler Tests of the Cen-ennial Exposition of 1876, 30 lb. from 100 deg. into steam of 70-lb. gage which requires 1115.33 B.t.u. per b.; and the evaporation of 30 lb. under these conditions requires

$$1115.33 \times 30 = 33{,}459.9$$

or dropping the fraction 33,460 B.t.u. per hour, which corresponds to

$$\frac{33{,}459.9}{970.4} = 34.48 \textit{ lb.}$$

rom and at 212 deg. The Committee of Boiler Tests of the American Society of Mechanical Engineers recommended that this shall be considered equal to 34.5 lb. from and at 212.

To determine the percentage of the rated capacity divide the horsepower as determined by the test by the rated horsepower and multiply by 100. Thus if the boiler in the above test were rated at 350 hp. it would have been running at

$$\frac{407.79 \times 100}{350} = 116.51 \textit{ per cent.}$$

of its rated capacity or 16.51 per cent. above its rating.

If it were rated at 500 hp. it would have been running at

$$\frac{407.79 \times 100}{500} = 81.56 \textit{ per cent.}$$

of its rated capacity, or

$$100 - 81.56 = 18.44 \textit{ per cent.}$$

below its rating.

With Superheated Steam

If the steam were superheated instead of moist it would be necessary only to use the value for the total heat of the superheated steam (which may be found in the Marks-Davis table for superheated steam) in the same process as above, except, of course, that there is no correction for quality. Suppose, for example, the conditions and results were the same as before, except that the steam instead of having the quality 96.5 per cent., i.e., carrying 3.5 per cent. moisture, were superheated 100 deg.

The table shows that to make a pound of steam of 137 lb. pressure, superheated 100 deg. from feed water of 32 would take 1247.4 B.t.u. The feed water at 196 deg. has already in it 163.92 B.t.u. above 32. The heat required per pound is therefore

$$1247.4 - 163.92 = 1083.48 \textit{ B.t.u.}$$

In this case all the water fed to the boilers

$$137{,}642 \div 10 = 13{,}764.2 \textit{ lb. per hour}$$

was evaporated. The boiler, therefore, absorbed

$$13{,}764.2 \times 1083.48 = 14{,}913{,}235.416 \textit{ B.t.u. per hour}$$

which is equivalent to

$$\frac{14{,}913{,}235.416}{33{,}460} = 445.7 \textit{ boiler horsepower}$$

Correcting for Leakage

Suppose that during the test the boiler or some of its connections below the water line, as the blowoff valve or pipe, commence to leak. It does not make any difference if the leak is where it will blow steam. If the boiler has made the steam, that is all we want. We do not care, so far as the purpose of the test is concerned, whether the steam blows out of the safety valve, or out of a leaky joint or goes to a condenser directly or through an engine. But if some of the water, which has been credited to the boiler is got rid of by leakage instead of by evaporation, less heat has been absorbed and a correction must be made for it.

To make this correction the amount of leakage and the average temperature of the leaking water should be known. If the temperature is above 212, some of the water will turn into steam as soon as it gets outside the boiler and it may be necessary to measure the quantity by measuring the drop of the water line in a given time, when no steam is being taken from the boiler and the pressure is constant at that of the test, or the rate of feed necessary to keep up with the leak. It may be hard to determine the temperature of the escaping water, which may not be that due to the pressure of the steam. But this article is upon working up a boiler test, not upon making one. Assuming a test with results as given above, 100 deg. superheat, 880 lb. leakage; temperature of leaking water, 340 deg.; what is the horsepower?

We must subtract from the water credited to the boiler this 880 lb. which it did not evaporate.

137,642 — 880 = 136,762 *lb.*

evaporated in 10 hr., or 13,676.2 lb., per hr. We found above that it required 1083.18 B.t.u. per pound so that the water evaporated represents.

13,676.2 × 1083.18 = 14,813,889.176 *B.t.u.*

But in addition the boiler absorbed the heat, which was used to heat the water which leaked

1 lb. at 340 deg. carries 311.00 B.t.u. above 32
1 lb. at 196 deg. carries 163.92 B.t.u. above 32

147.08 B.t.u. added

The 88 lb. leaked per hour would then have taken out of the boiler more than they brought in

147.08 × 88 = 12,943.04 *B.t.u.*

The boiler has absorbed the heat and when the leak is stopped it will be useful for making steam. If we want to know the capacity of the boiler when it is not leaking we must credit it with this heat

11,817,889.176 B.t.u. used in evaporation
12,943.04 B.t.u. lost by leaking

33,478.8) 11,804,946.136 B.t.u. absorbed per hour
342.2 boiler hp.

In the case of the boiler making moist steam, some of the heat which is absorbed by the boiler goes off in the entrained water which is heated from the feed to the steam temperature. If the steam is to be used for driving a turbine or engine this moisture is worse than useless and the boiler should get no credit for the heat which it carries off. If the steam is used for heating or processes this heat may be as useful as any other, and will be credited to the boiler or not, according to what you are trying to determine by the test.

When we come to making up a heat balance and finding out what has become of all the heat in the fuel this item will have to be reckoned with, but that is another story.

⁂

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Some interesting boiler installations are found. Many of the boiler furnaces were equipped with in-swinging fire-doors which are a safeguard to the firemen. The appearance of one engine room is a surprise, because of its neatness and general layout; the engineer relates the "story of his life."

⁂

Traveling about the mines with Hunter, together with the visits made alone, had given me a pretty good insight regarding the mechanical end of mining coal. I found that at anthracite-mine boiler plants hand firing was used altogether, as buckwheat coal was burned. A general practice is to have wooden coal bunkers built the length of the boiler house in front of the boilers with openings at the bottom, through which the coal comes out onto the boiler-room floor handy for the fireman. This is shown in Fig. 1.

On many of the boiler furnaces weighted, tilting doors are used, which are a safeguard to some extent against injury from bursting tubes, because if one does fail the pressure in the furnace tends to shut the doors tighter, and they cannot blow open. Of course, if a tube bursts

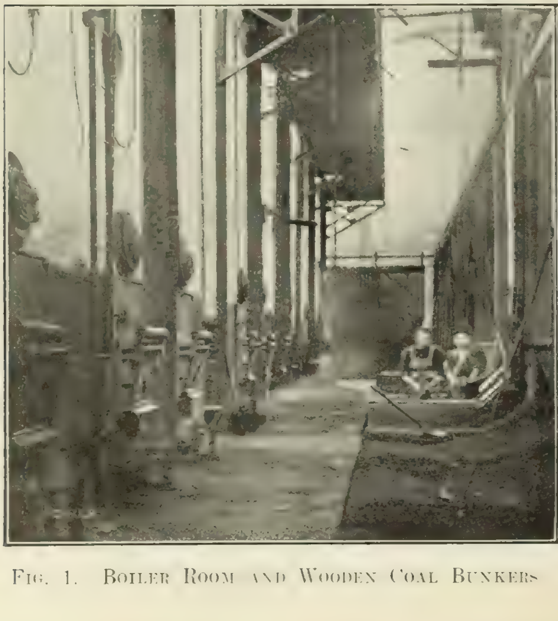


Fig. 1. Boiler Room and Wooden Coal Bunkers

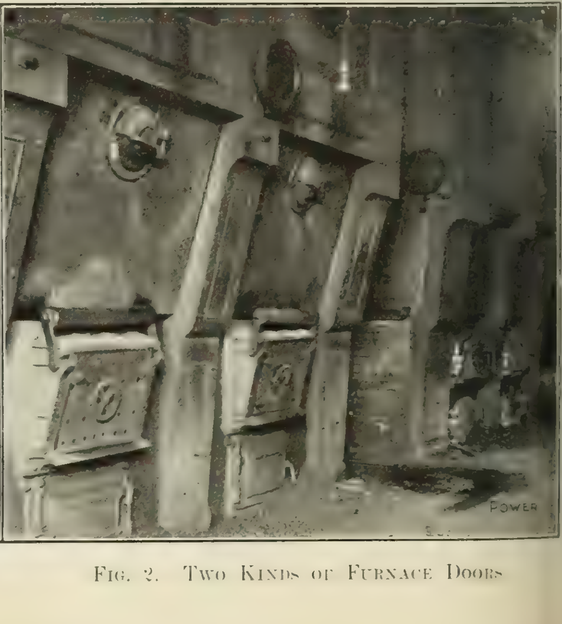


Fig. 2. Two Kinds of Furnace Doors

while the fireman is working on the fires, he is almost sure to be severely burned or killed. The value of these doors is indicated by the comparison of two kinds of furnace doors, shown in Fig. 2. There is nothing to prevent the doors shown on the second boiler front from blowing open in case a tube should burst.

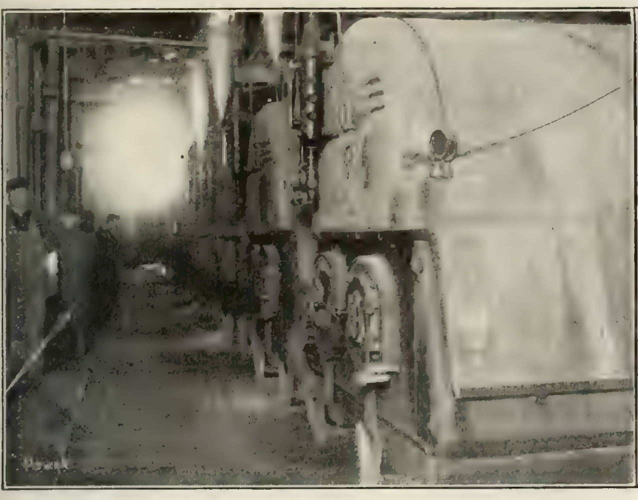


FIG. 3. BATTERY OF LOCOMOTIVE-TYPE BOILERS

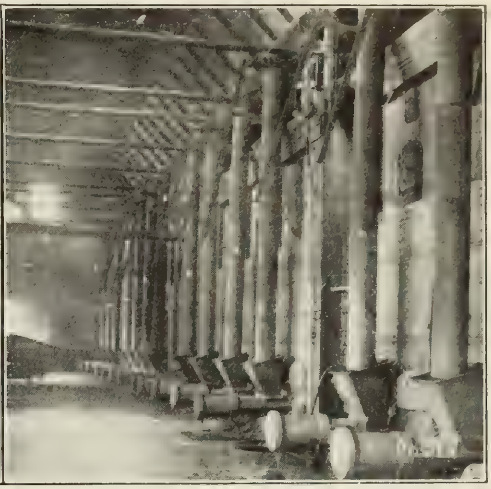


FIG. 4. WATER-TUBE BOILERS AND MECHANICAL STOKERS

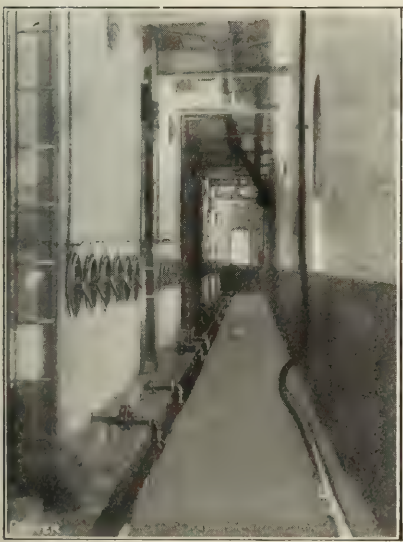


FIG. 5. REAR OF A BATTERY OF BOILERS

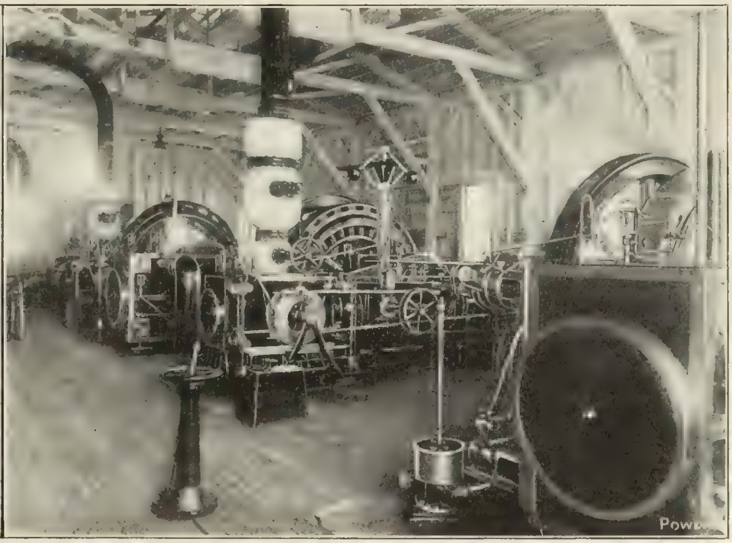


FIG. 6. CORLISS ENGINES AT A COLLIERY

The boilers shown in Fig. 3 are of the locomotive type, each of 350-hp. capacity, carrying a steam pressure of 115 lb. The furnaces are fitted with shaking grates and buckwheat coal is used. It is claimed by those in charge that they give very good results, but from the color of the iron smoke-stack it would appear that the gases escaping to the atmosphere were at a very high temperature. As in other boiler plants using anthracite coal, the supply was kept in a wooden bunker built in front of the boilers. In another boiler plant at a soft-coal mine I found stokers in use, Fig. 4, the fuel feeding from an overhead bunker, the coal supply of which was maintained by a belt conveyor. Coal fresh from the mine was dumped into the crushing rolls before reaching the conveyor.

In Fig. 5 is shown a view behind a set of water-tube boilers. This boiler plant was kept exceptionally clean, as indicated. A trough was made in the cement flooring along the length of boilers to take care of waste water, and the blowoff pipes from each boiler were placed in a trough which ran at right angles to the first. These troughs carried away any leakage water and permitted of washing down the floor with dispatch.

The clothes a man wears do not indicate the kind of a man inside of them. Neither does the housing of a power plant designate the kind of machinery likely to be found inside. In one instance the power house was built of wood, painted red. There was no outside indication that anything but the general run of dirty, noisy machinery would be found inside. It was, therefore, somewhat of a surprise to find a well laid-out plant containing two 16 and 26 by 12-in. and one 22 and 38 by 12-in. cross-compound, noncondensing Corliss engines, each directly connected to alternating-current generators. Then there was a motor-driven exciter unit, also a steam-driven exciter. The boiler plant contained six 250-hp. water-tube boilers, carrying 160 lb. pressure. Fig. 6 is a view of the engine room.

All of the machines were painted maroon color and were kept clean and bright by frequent wiping. The flooring, although of boards, was washed clean, showing that the engineer in charge had pride in the appearance of the plant.

After getting acquainted with the engineer and his assistant, I began asking personal questions. Bringing out a couple of ever-ready cigars and getting them properly burning, I asked Mr. Engineer how he happened to get into the game.

"It's the same in my case as in that of others," said he. "I began working about a mine long before I should have left school. My first job was as trapper boy, tending entry doors. When it came time to go home at night, I used to stop in at the pump rooms which were near the foot of the shaft, and watch the men."

"That showed you had the engineering germ. Most boys would have hustled to the surface to play ball or go fishing."

"Yes, I suppose so. As a result I finally got a chance to care for a small pump located in a narrow, dark, dirty hole, but for all that it was the greatest day of my life when I was first left alone with that pump. I felt as if the entire mine operation rested upon my shoulders.

"This advance opened my eyes and I saw that if I did not know more than I did at that time I would finish as a pump runner. I had often looked with longing eyes at the engines in the above-ground plant, but the engineer never allowed us boys inside. Finally a new man came on the job and I suppose my frequent visits to the engine-room door showed that I was considerably interested, and on one occasion he asked me to come in. Gee, that was a treat. The engineer answered my thousand and one questions readily and quite a friendship sprang up between us."

"It wasn't long before I determined to become a stationary engineer and I began to study nights, pick up a little information here and a little there. Finally I got in with my engineer friend as assistant engineer, after serving a time as a fireman, and, some years later, when my chief left to go to a better job, his place was offered to me, which I did not refuse, you may rest assured. But if it had not been for the instruction my chief had given while with him the job would have been beyond me. I was in that plant until this one was built, when I came here, as you see. That's about all there is to it; lots of hard work, knocks and a determination to be something besides a miner's helper."

It was dark before I left the plant, and as I carefully picked my way over the rough ground toward the village, I realized more than ever that it is not luck that places a man in a position, but that it is the determination to make something of himself that helps him to win out in the struggle.

Flow of Steam in Pipes

In the *Wisconsin Engineer* for November, Prof. D. E. Foster gave an interesting chart for determining the size of steam pipes. The chart, which was based on a formula by A. E. Berggren, is reproduced herewith.

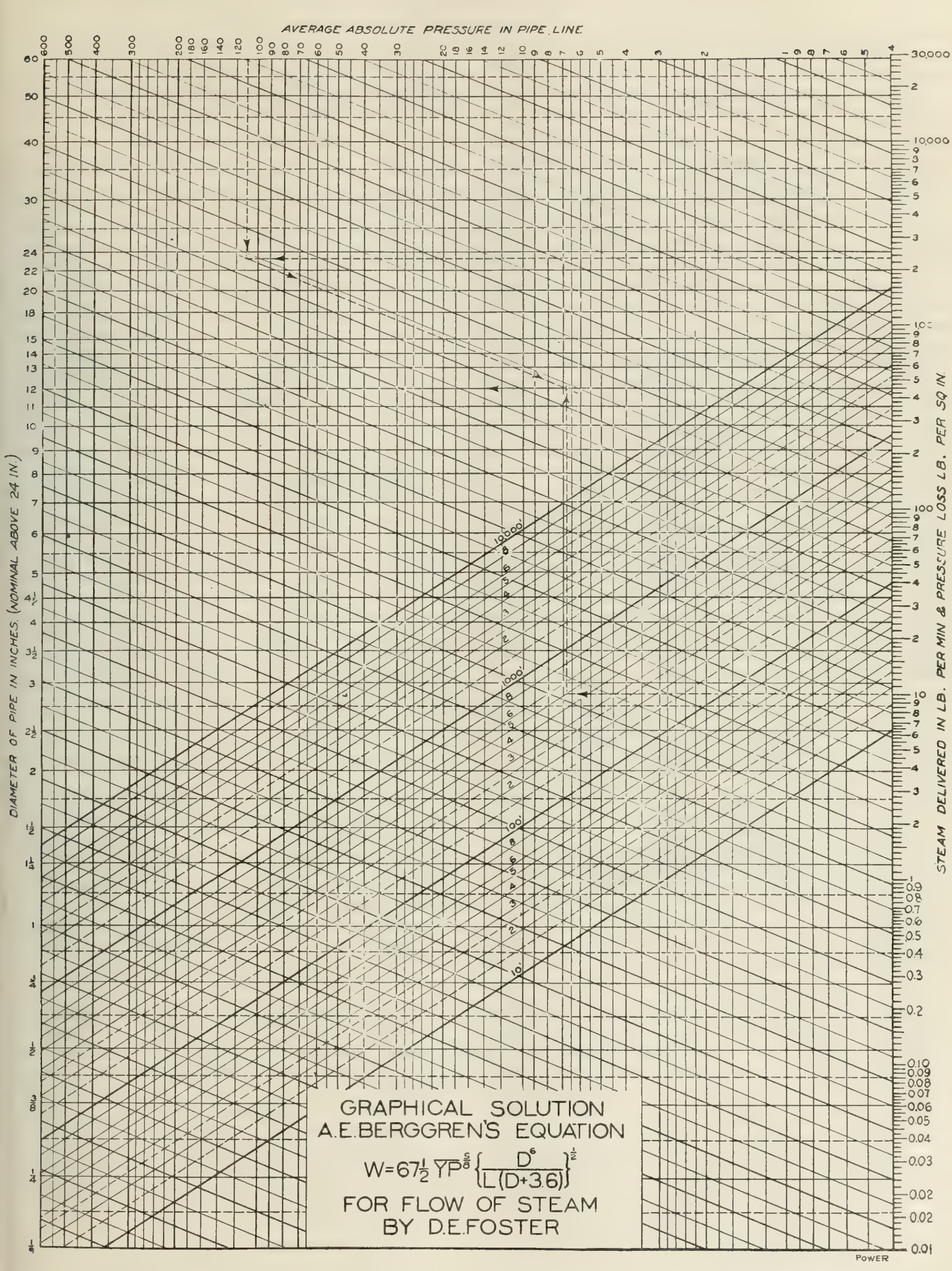
As a general rule, the engineer has a machine demanding a certain quantity of steam, located at a given distance from the source of supply, the initial pressure of which is a fixed quantity, and he wishes to allow a certain drop of pressure between the source and the machine. This drop is generally between ½ and 4 lb. per 100 ft. of pipe. With these data at hand, he must determine the size of the required pipe. Suppose that 2300 lb. of steam are required at a machine 500 ft. away from a boiler under a pressure of 115 lb. abs., and that the total drop is to be 10 lb., or 2 lb. per 100 ft. The average pressure in the pipe line then will be 110 lb.

Referring to the chart, the intersection of a horizontal representing 2300 lb. of steam with a vertical representing 110 lb. average pressure in the pipe line will determine a diagonal. The intersection of this diagonal with a second vertical, determined by the intersection of a second horizontal representing 10 lb. total loss of pressure, and a second diagonal representing 500 ft. of pipe line, will determine a third horizontal giving 12 in. as the proper size of pipe. The solution of this problem has been indicated on the chart by dotted lines and arrows.

The chart may be used to determine quantity when the other four factors are known or assumed. Suppose that the demand in the problem given above be increased in the future to 3200 lb. by the installation of a larger machine. If the initial pressure remains the same, the drop in pressure will have to be increased. In this case the drop must be estimated. If it be assumed to be 18 lb., the average pipe-line pressure will be 9 lb. less than the boiler pressure, or 106 lb. Following through the chart as before, the probable loss will be 17 lb. This value is so close to the assumed value that it will be unnecessary to check it.

As another example, assume that the demand be increased to 5000 lb. per min., that the pressure at the machine be increased to 140 lb., and that the initial pressure necessary to deliver this quantity is desired. It will be seen that the drop in this case is also unknown; hence the probable loss will have to be estimated. Assuming that it will be 20 lb., the average pipe-line pressure will be 150 lb. Using these data, the corresponding loss is 25 to 26 lb., which indicates that the initial pressure should be about 165 lb. Taking an average pipe-line pressure of 152.5 lb., a further check shows that this figure is about right.

In the first problem the solution gave 12 in. exactly. Generally speaking, however, the solution of such a problem will give a size other than standard, in which case either the size above is selected, and the pressure loss is decreased, or the size below and this loss increased.



GRAPHICAL SOLUTION
A.E.BERGGREN'S EQUATION

$$W=67\tfrac{1}{2}\,YP^{\frac{5}{8}}\left\{\frac{D^6}{L(D+3.6)}\right\}^{\frac{1}{2}}$$

FOR FLOW OF STEAM
BY D.E.FOSTER

Grounding Methods and Devices

By John A. Randolph

SYNOPSIS—The necessity for grounding, methods commonly employed and the precautions to be observed.

*

The subject of grounding is simple from the construction standpoint, but it nevertheless requires careful attention and foresight if the best results are to be obtained. In general, there are two purposes for which grounding is employed, namely, to provide an indispensable part of the working circuit, as in the lightning arrester, the ground detector and various ground return systems; and for protection, as in the case of all grounded cable sheathings, pipes, frameworks, three-wire neutrals and transformer secondaries. It is important that the grounding connections and circuits provided for both of these general functions be in good working order at all times. However, on purely protective systems, it is possible for faults to pass unnoticed indefinitely unless the system is given careful attention. The existence of a fault on such a system may result in serious accident by preventing the operation of the system. There is always the possibility of a breakdown in the insulation of a wire or cable which may cause the sheathing, piping or other adjacent metallic parts to become alive. With these parts well grounded, there is little danger of accident, as the ground connection will form a short-circuit which will either operate the fuses or automatic cutouts on the faulty circuit or by providing a continuous path of low resistance to the escaping current, will afford a safeguard to life and property which would otherwise be endangeared by contact with the live parts.

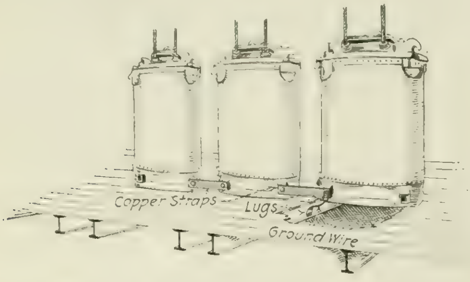


Fig. 1. Showing Method of Grounding Transformer Cases

These protective measures should be carried out not only on the conductors themselves and their adjacent metallic parts, but on all metallic sheathings, piping, framework, casings and details which may form a part of the structure or apparatus used in the control and distribution of high-voltage currents and which are so located that they could possibly become alive through the breakdown of insulation on the working circuit. This includes all oil-switch steelwork, current-transformer supports and the casings of potential transformers. Moreover, where step-up or step-down transformers are used, their casings and supporting steelwork, if any, together with any cable supports of steel, should be grounded unless already rendered safe by insulation. A convenient means of grounding transformer casings is shown in Fig. 1. This injunction also applies to generators, motors, rotary converters and other machinery which may be carrying dangerous voltages.

Methods of Grounding

There are three fundamental requisites to consider in providing a ground: First, it should be permanent and stable; second, it should have low resistance, and, third, it should be of such a nature as not to suffer readily from deterioration. No ground should be used which is likely to be disturbed for any reason. Furthermore, grounds should be avoided which will offer appreciable resistance to any currents which are likely to flow through them. For this reason, long lengths of small water pipes should be avoided, as should also any devices which, on account of corrosion, a lack of earth moisture, or for other reasons show a high resistance. Reliability at all times together with a minimum of care and inconvenience is the prerequisite of all such systems.

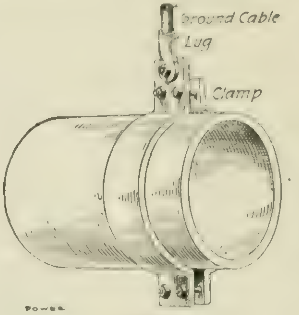


FIG. 2

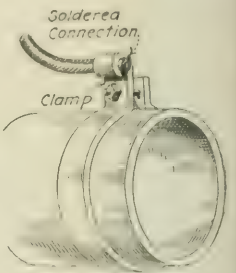


FIG 3

Two Ways of Securing Ground Wire to Pipe

Various methods are employed in grounding, but it may be said that in general, they can all be classified under the following headings: Those making use of the building steel; those in which the ground conductor is connected to pipe lines, rails or other existing metallic circuits, and lastly those employing plates, pipes or other devices buried in the earth and used exclusively for grounding.

Grounding to the Building Steel

The grounding circuit in this case should be connected to the steel at the nearest point, long runs being avoided in order to reduce as far as possible the danger of a break in the circuit from outside causes. The conductor should be rigidly fastened to the steel by bolts, the surface of the steel at the point of contact having first been scraped clean of all paint or corrosion. An area of contact should be provided between the conductor and steel sufficient to render the resistance as low as possible. Where the conductor consists of wire or cable, lugs should be used at the grounding points.

Grounding to Pipe Lines

When the ground connection is made to pipe lines, water pipes should be used if possible. The pipe must be large enough to carry any currents which may flow and the location of the connection should be such that the likelihood of a disconnection of that portion of the pipe for repairs or other purposes is remote. For this reason the conductor should be connected outside the water meter if the public mains are used. In all cases, the connection should be made as near as possible to the point where the pipe enters the earth. The connection may be made by a clamp or by a brass plug into which the conductor has been firmly soldered. If a clamp is used, it should be so constructed that by turning up on bolts or screws, it can be made to fit the pipe snugly. It should further be designed to afford a proper connection with the conductor either by a lug, if the conductor is of large cross-section, as shown in Fig. 2, or by a loop into which the conductor can be soldered, if of small cross-section, as shown in Fig. 3. The pipe, at the point of connection, should be scraped clean of rust, paint or other foreign matter before the clamp is attached, in order that the best possible contact may be made. The material for the clamp should be rolled copper. With such a clamp, the area of contact should be figured for a carrying capacity of 150 amp. per sq.in. For the cross-section, a capacity of 1000 amp. per sq.in. may be used.

If plugs are used they should be screwed tightly into a pipe fitting or into a hole tapped into the pipe itself if the latter is of cast iron. The practice of grounding to rails is so common as to call for but passing comment. It finds its chief application in the grounded return circuit of electric-railway systems. On such a system the rails may also be used for protective grounding.

Ground Plates

In the use of devices employed exclusively for grounding, the construction depends largely upon the condition of the soil, upon the proximity to a body of water, upon the nature and extent of the various circuits connected thereto, and upon the personal tastes of the designer. One of the most widely used and approved devices consists primarily of a copper plate, as shown in Fig. 4. It should be of a thickness sufficient to prevent it from soon being destroyed by corrosion and also to afford sufficient mechanical strength. A thickness of from 1/4 to 3/8 in. will suffice for most cases. For the best results, the plate should be located, if possible, in a place where the earth is permanently damp, and placed about eight feet below the surface. Around the plate on all sides should be placed a quantity of crushed coke, and to the plate should be securely fastened, preferably by rivets, a piece of copper bar or cable of a length sufficient to allow it to protrude a short distance above the surface of the earth. Iron pipe should never be used for a covering of this conductor if the latter is to be connected to lightning arresters. This is because of the impedance or choking effect which the iron pipe would exercise against oscillating currents. If pipe is used at all, it should be of brass. After the coke has been placed around the plate, it should be thoroughly moistened before the hole is filled with earth.

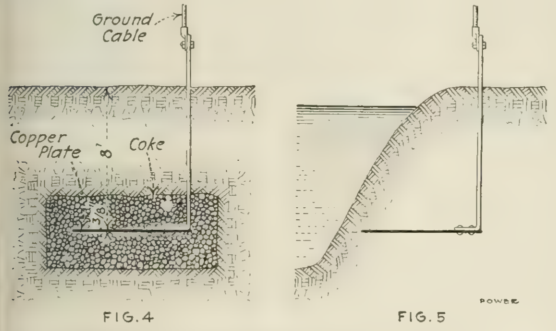


FIG. 4 FIG. 5

Grounding Plates Imbedded in Earth

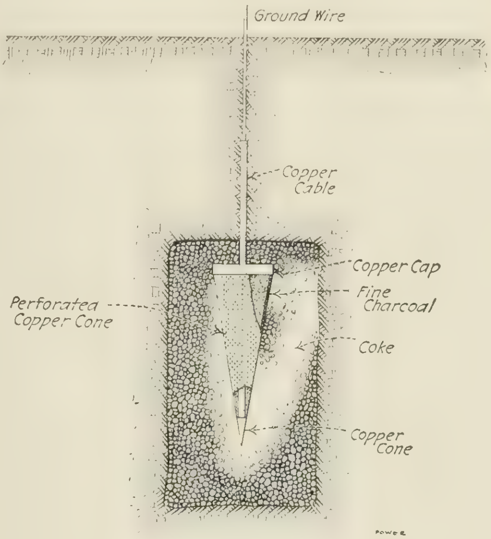


Fig. 6. Ground Cone

Another method of grounding by a plate in locations where a stream or other body of water is available, consists in placing a copper or iron plate in the mud at the bottom or along the banks, as in Fig 5. The plate should be buried to a depth sufficient to prevent it from being disturbed. Rocky bottoms should be avoided if possible. The plate should never be suspended nor should it be allowed to rest lightly on stones or gravel.

Another method in common practice consists in the use of iron pipes driven into the earth for a distance of about eight feet. The earth should be as moist as possible. To insure a good contact, it is well to pour a quantity of salt water around the pipe. This procedure can be facilitated by having the lower end pointed and perforated. The salt water can then be poured into the pipe and diffused into the earth about the lower end of the pipe which is difficult to reach otherwise. In the use of pipes it should be borne in mind that enameled conduit ought never to be employed because of its insulated condition.

Ground Cones

A device for which good results are claimed consists of the ground cone, a leading form of which is constructed as shown in Fig. 6. It consists essentially of a perforated hollow copper cone filled with fine coke or charcoal and having at its apex a copper point to which is attached a copper cable. A copper cap fits over the top of the device, as shown. The ground conductor is soldered to the cable. A quantity of coke placed around the cone improves the efficiency, but is not absolutely necessary. The function of the charcoal or coke within the cone is to absorb moisture from the surrounding earth, thus insuring good contact. The perforations allow this circulation of moisture and also render a more pronounced contact between the copper and its surrounding elements.

GROUNDING OF SECONDARIES

This subject has been much discussed in recent years, owing to the varied opinions as to the advisability of the procedure. However, it is now commonly conceded that the grounding of transformer secondaries which supply current to customers and which carry voltages of 150 or less should be mandatory and that beyond that voltage, it may be permitted up to a voltage of 250. The object is to reduce as far as possible the danger to life and property which otherwise would result from a breakdown of insulation and the consequent crossing of transformer primaries and secondaries.

The usual procedure on systems employing a neutral is to ground the latter. On a single-phase system with a three-wire secondary, this can be done, as shown in Fig. 7, where one transformer is used, or, as shown in Fig. 8, if two transformers are used. If a neutral is not available, one side of the system should be grounded, as in Fig. 9. In Fig. 10 is shown a grounding connection for a two-wire, single-phase system with two transformers whose primaries are connected in series and the secondaries in multiple.

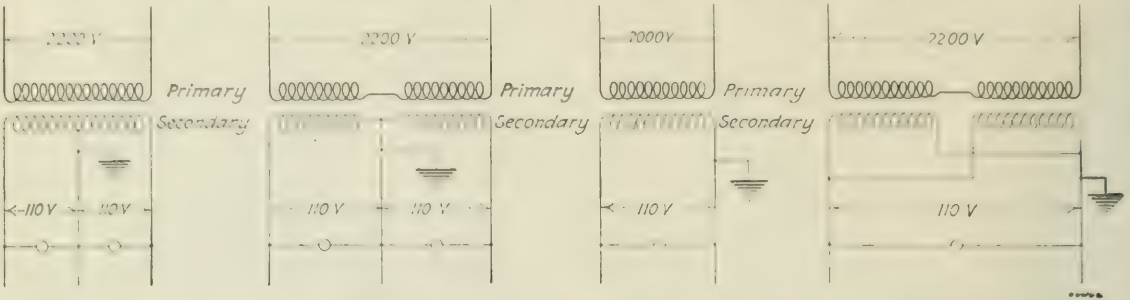


FIG. 7 FIG. 8 FIG. 9 FIG. 10

METHODS OF GROUNDING TRANSFORMER SECONDARIES

⁂

Smoke Formation and Prevention

The formation of smoke is due to failure to burn the combustible gases which are driven off from fresh bituminous coal (or other fuel of similar characteristics) when it is exposed to the heat of the furnace. These gases are a complex mixture of various hydrocarbons, from some of which carbon separates on cooling, in the form of lampblack or soot. The smokier fuels also give off tarry vapors, which condense and help to gather the carbon particles into flakes or "smuts."

For the burning of these gases as they are evolved from the coal, three conditions must exist: Air must be supplied above the fuel bed, the temperature must be high enough to insure ignition, and there must be time or space for combustion before the mixing currents of gas and air are cooled by flowing into or among the tubes of the boiler.

The surest way not to meet these requirements is to fire coal in large quantities at a time. This causes the temporary production of so much gas that neither air supply nor combustion space can possibly be sufficient for its burning; it also aggravates the trouble by cooling the furnace below the temperature of assured ignition.

With ordinary hand-fired furnaces, the formation of smoke can be greatly diminished, if not almost prevented, by putting on coal in small amounts at short intervals, with proper regulation of air supply. Much depends upon the kind of furnace. A roomy one, with brick walls and perhaps a brick arch roof (these being hot enough, in service, to ignite gas), is inherently less likely to give off smoke than a low furnace, especially if it has the water-cooled walls found in internally fired boilers.

The rate of combustion has an influence similar to that of the size of the combustion space. Then as a boiler is more heavily loaded, there is more chance for benefit from some one of the many schemes that have been proposed for injecting jets of air above the fire. The action of these jets in stirring and mixing air and gas favors rapid combustion.

There is a limit to frequency of firing by hand, in the strain it entails upon the fireman and in the undesirability of having the furnace doors open so much of the time. The necessity of compromise with these elements is eliminated by the use of mechanical stokers, which offer an effective means for securing and maintaining proper conditions of combustion.

On general principles, it matters but little whether the stoker is of the back-feed type, with the bed of fire slowly moving forward, or of the underfeed type. The essential thing is the continuous supplying of coal, without disturbance of draft conditions (by opening of doors) and with but small and slow variations in requirements as to proper air supply.

⁂

Coke-Oven Gas for Steam Generation—Extensions are to be made to the Dunston Power Station, near Newcastle-on-Tyne, which will be remembered in connection with some of the best turbine efficiencies that we have published. An agreement has been entered into by the Newcastle-on-Tyne Electric Supply Co., Ltd., with the Teams By-Products Co., Ltd., to purchase the surplus coke-oven gas from a large battery of ovens situated about 1½ miles from the Dunston Station. The gas will be used as fuel under the boilers. Extensions to the generator plant will consist of a 12,000-kw. turbo alternator, built by Brown, Boveri & Co., and run by a Richardson-Westgarth & Co.'s turbine.

Editorials

A Helping Hand

In the cartoon this week is indicated a good combination to assist to success the chap who is not afraid to shoulder a little responsibility. It used to be thought that theory and practice were about as harmonious as a losing baseball team is with the umpire. It was thought that "theoretically" and "practically" referred to two entirely different conditions and were in two different worlds.

The beetle-browed practical man of the old school—"no school" would perhaps be a better term—noticed that the textbooks began a severely practical question with such words as "disregarding friction." It also came under his observation that machines have an unshaken determination to regard friction. So he considered the theory to be wrong and worthless.

If this old scholar—or "no scholar"—had an engine with its valve-gear removed, he would not junk it as worthless. But that is what he is doing with his theory when he discards it simply because it is incomplete. Fortunately, the junk heap is more littered with specimens of his kind than with discarded theory.

Nowadays the man on the job is more or less of a theoretician or a failure. Even the dyed-in-the-wool practical man, if successful, knows more theory than many a college cub.

Don't junk your theory, even if, at the time, it doesn't deliver just the goods wanted. Save it until you can use it.

Two Startling Suggestions

When fuel is burned under a boiler more or less of the heat is dissipated before it gets into the water, and the products of combustion, bearing more or less heat, have to pass off by the chimney. In the Brünler system, described by Geheimrath Jaeger in the *Zeitschrift für Dampfkessel und Maschinenbetrieb,* the fuel, coal tar, is burned under water and under pressure, the products of combustion going with the steam into the engine. Air for combustion must, of course, be supplied under pressure, but by expansion in the engine or turbine it gives back the work required to compress it.

Another startling suggestion is to substitute mercury for water as the working fluid of a heat engine. The efficiency of a heat engine is measured by the temperature range through which it can be worked, and as the attainable low temperature is fixed by our environment, high efficiency involves a high initial temperature. With water, the pressure goes up rapidly with increasing temperatures, being 200 pounds for 382 degrees, nearly 250 pounds for 400 degrees, 421 pounds for 450 degrees, 684 pounds for 500 degrees, etc. With such a rapid increase in the pressure, per additional degree, a practical limit of pressure is reached at a comparatively low temperature.

The boiling point of mercury, however, is 680 degrees at atmospheric pressure. The idea is to generate mercury vapor under pressure, work it in an engine, exhaust it through a heater, where it is still hot enough to make steam of considerable pressure, but in which it will be condensed. The steam is used in a turbine.

This constitutes a binary vapor engine with water as the lower pressure fluid, whereas in that of Professor Josse the water is the higher pressure fluid, and bisulphide of carbon or some other fluid having a low boiling point the secondary.

The water or mercury vapor could itself be expanded to the lowest available exhaust temperature, but it would take on a volume which would be impracticable to handle. This lower volume at low pressure is, in the Josse engine, made to pass its heat to the volatile fluid, which, with the same heat at the same temperature, generates a small volume of vapor at a high pressure, available for further expansion in a cylinder of practicable dimensions.

Technical Methods in Boiler-Room Operation

More and more attention is being given to steam generation, for power-plant officials and owners are gradually realizing that in the boiler room is spent the greater part of the cost of power production.

That power-plant men have arrived at this point and are adopting more scientific and uptodate methods, are hopeful signs of the progress being made in power-plant engineering. Yet, it may be asked, "What percentage of the power plants throughout the country of any considerable size are properly equipped to take advantage of technical methods of operation?

While the subject of combustion has received more or less consideration, still it is safe to assert that not 10 per cent. of the chief engineers in the United States are able to operate an Orsat apparatus for the analysis of the gases passing through the flue. This condition is not past mending, as the signs of the time are toward constant betterment and a rise in the technical status of engineers. Those of the rising generation are qualifying themselves by study and investigation to bring the engineering profession to the high level where it rightly belongs.

No engineer is fully competent to manage a boiler plant, particularly a large one, who is unable to manipulate an Orsat apparatus and correctly interpret the information obtained from it. He should be able to determine the British thermal units per pound of fuel by the use of a calorimeter, and also the percentage of moisture, ash, sulphur, etc. He should know how to make a quantitative, or at least a qualitative, analysis of the boiler-feed water and of the scale found in the boilers, and to at least provide suitable temporary treatment. These requirements may appear excessive, yet, with diligent study these things may be accomplished in a short time by any man of the caliber required for this important branch of steam engineering.

The analysis and treatment of boiler-feed water does not always require the services of a chemist versed in all the branches of organic and inorganic chemistry, and the same holds good with the testing and analyzing of fuel. An engineer at present in charge of a large boiler plant took up the study of these branches some three years ago, and was able to make his analyses check closely with those of the professional chemists.

These technical methods of plant control are of proved value to the engineer.

The Responsibility of the Engineer

At a recent gathering of engineers, a distinguished designer of electric machinery opened his private records and data and discussed frankly the wreck of a generator, for the design, construction and test of which he was solely responsible. The speaker showed photographs of the plant before and after the disaster, lantern slides of the machine's construction, a typical polepiece lamination and other details of interest, practically laying bare every circumstance associated with the unfortunate event and magnanimously assuming the lion's share of the blame for what might have been a terrible fatality. Plainly everyone present was impressed with a realization that the lessons of failures and operating troubles are invaluable to all who are striving for perfection in their tasks and that the responsibilities which must be carried by every designer, builder and user of high-powered generating machinery are great.

Terrific forces are held in leash in a generator of the size involved in this accident, 9000 kilowatts. Built for operation by a waterwheel at 300 revolutions per minute, the peripheral velocity of the rotor was about 175 feet per second, which, at the time the generator was designed, was daring. The rotor was a solid disk, a nickel-steel forging, bolted to two shaft or journal ends. On each side of the solid disk was bolted an annular nickel-steel forging about nine inches wide and into the rotor were dovetailed ten polepieces weighing 5000 pounds each. The radial force on one of these polepieces reached the enormous total of nearly three million pounds with the machine operating at normal load and speed. During the test the unit was being speeded toward the specified maximum of 500 revolutions per minute, when, at 460 turns, one of the rotor forgings burst and the machine was wrecked, fortunately with no loss of life.

The accident afforded many lessons for the designing engineer, which the operating engineer also may take to heart in dealing with the important problems of purchasing apparatus and supplies.

What precautions are needed to avoid recurrences of this sort? First, in dealing with high-speed machinery, whether on the designing board or in the plant, whether in process in the factory or assembled in the test room, the limitations of employees having to do with such apparatus should be known by the man finally responsible. Some one solely responsible should see that the calculations of the designer are checked by the highest authority obtainable, that the quality of materials furnished is equal to that demanded by the specifications, and that the fabrication of material subjected to heavy mechanical or electrical strains accords with the latest knowledge regarding the effects of manipulation, heating, cooling and tooling upon the material dealt with.

Where heavy high-speed machinery is involved no detail of working the stock which goes into its structure is beneath the attention of the wise purchaser. Such an apparently trifling detail as the omission of a fillet or the marring of a bulky nickel-steel casting by tool marks may lead to disastrous results. Too much faith in the assurances of the manufacturer as to the reliability of parts or material to be used in lines outside those immediately familiar to him is likely to lead the engineer astray, and an easy-going dependence upon former practice without independent criticism of its adaptability to the new conditions is rash.

The engineering industry owes a debt to science for the fundamentals of its progress and in the intense commercialism of the present day it needs more of the true scientific spirit in attacking new and difficult problems which never can be solved on the bargain-counter basis. This does not mean that reliance cannot be placed upon manufacturing concerns of long-established reputation in filling the requirements of the operating engineer, but it does mean that where very striking departures from previous practice are indicated as desirable, either in method, design, size of equipment, factory treatment or acceptance trials, sole dependence safely cannot be placed upon the organization supplying the apparatus. Either one of the purchaser's staff, or his consulting engineer, should investigate the problem, not upon the basis of "who is right and who is wrong," but upon the much more important guidance of "what is right and what is wrong."

The Language of Ordinances

How easy it is not to say what one means is instanced by the first section of an ordinance recently adopted by the council of the city of Reading, Penn., providing for the inspection of steam boilers and the examination and licensing of engineers.

> BE IT ORDAINED BY THE COUNCIL OF THE CITY OF READING, that the office of boiler inspector be and is hereby created, whose duty it shall be to issue a license to any applicant therefor who has charge of or operates a steam boiler or steam engine over 10 hp. in the city of Reading, etc.

To say nothing of the fact that the "whose" refers, in the letter—but not in the intent—of the ordinance, to the office instead of the inspector, the section as read makes it the duty of the inspector to issue a license to any applicant therefor, and the succeeding sections do not make this any less mandatory. The second section says that it shall be unlawful, etc., for one to run a boiler or engine, unless such persons shall, on or before Feb. 1, 1914, apply to the boiler inspector of the City of Reading for a license, who (the license ?) shall upon a proper examination of the applicant, grant him a license for the term fixed by said act.

While the intent of the act is perfectly clear, it would have been better to have expressed that intent grammatically and precisely. The salary of the inspector is fixed at the sum of $1500 per annum. It is to presume that this is simply an office which can be filled in connection with other duties. To specify such a salary as compensation for the full time of a man who is in supervisory charge of all the engineers in Reading, would be to set a miserably low standard for the wages of the craft in that community.

Correspondence

Removing Frost from Direct-Expansion Coils

The opinions in the Feb. 7 issue as to the merits and demerits of thawing refrigerator coils with hot gas as described by Mr. Thurston, in the Jan. 6 issue, were interesting. I have used this method for over fifteen years and have made provision for it in every plant of which I had charge, including packing-houses, cold-storage, brewery and ice plants. It is not only the most effective but also the cheapest and quickest way of thawing all direct-expansion coils; it is also safer, if the system is installed and operated properly, than knocking or scraping off the ice.

If the plant is large, the main hot-gas pipe should be of 2-in. size and the branch pipes 1¼ in. in diameter between the expansion valve and the cooling coil. If the main line is of considerable length or runs through cold rooms, it should be insulated. In our plant, I have installed two hot-gas main lines, 150 ft. long, 2 in. in diameter. They are not insulated pipes and the loss of heat before entering the 2-in. coils is not enough to warrant the expense of insulation. There is little heat lost because the gas is superheated.

To thaw ice from the coils, I first close the expansion and the return valves, then open the 1¼-in. valve gradually to avoid the hammering in the coil caused by the oil and foul liquids which are present in almost all coils. While the hot gas is slowly flowing into the coils I open the return valve and regulate it so that the suction pressure increases not over 2 lb. above the usual pressure. This increase of pressure, and therefore increase of temperature, of the ammonia within the system from which the coils are cut off, will not seriously affect the temperatures in the other coolers. I have not had as much as ½-deg. F. increase in any room during the thawing.

Wherever practical, the freezing coils in the different rooms should be divided into two or more separate coils, thus keeping the one coil going while thawing the other. Mr. Solomon's practice of knocking or scraping off the ice is dangerous, for the coils may be corroded, and serious leaks result from this practice. This cannot happen if hot gas is properly used.

William Schliemann.

Washington, D.C.

Replying to Mr. Ohphuls' comment, I willingly acknowledge that frost may be removed with hot gas, but I contend that it is a poor way of doing it.

Suppose an ice machine is working on six freezer rooms to be kept 10 deg. F. above zero, and they are piped with 2-in. direct-expansion coils having a coating of hard frost about an inch thick. It is decided to thaw the frost from the coils in one room with hot gas. The suction valve is first closed and the hot gas allowed to enter the coil. This gas will condense into a liquid as soon as it enters the frosted coil in the cold room. The liquid will again evaporate as it travels through the pipe and will not have done any thawing so far. The temperature in the coil will have to be raised to cause thawing, and to get this sufficiently high temperature, the pressure will have to be about 50-lb. gage in the coil. To get this pressure in a cold room, the coil will have to be nearly filled with liquid; then, and not before, the frost will begin to drop off.

How much work will the ammonia compressor be doing on the other five rooms? Not much, for the working charge of ammonia will be so small that the machine might just as well be shut down entirely. It will take quite a long time to fill the coil with liquid by using hot gas and, as that is what must be done in the end, I think that the quickest way will be to use liquid from the receiver through the regular expansion valve. Do not expect to work the expansion valves on the other rooms while nearly all the ammonia is working as a frost remover.

My experience teaches me that the best way to combat the frost evil in cold rooms is to clean the frost off at regular intervals with scrapers. Do not let the frost become heavy as it will act as an insulator. When the frost is an inch thick, at the most, it is time to clean it off. A steel scraper bent to fit the pipe will do the cleaning quickly, cheaply and safely. Do not hammer the coils, for leaks are likely to develop in the pipe seams.

A. G. Solomon.

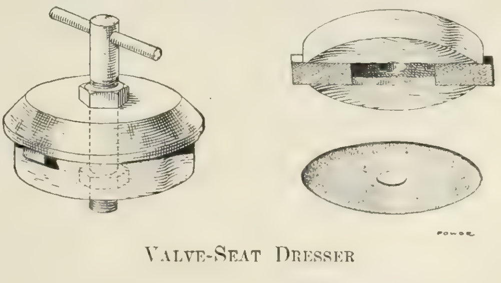
Chicago, Ill.

⁂

A Valve-Seat Dresser

I had a large boiler-feed pump, the valves and seats of which were badly scored. The seats were merely round bushings of brass, which I attempted to remove and dress in the lathe, but not having the proper tools, I had to do the job another way, which I will try to describe.

I first found a cast-iron disk 5¼x1¼ in. and faced one side off in the lathe, then drilled and tapped it for a ⅝-in. bolt with a long thread and locknut on the top side. I then fastened to it a piece of ⅞-in. pine board and turned it down to a disk 4 in. in diameter to serve as a guide. In the side of this board next to the disk I cut a groove 1¼ in. wide by ¼ in. deep, shown in Fig. 1. I next broke off two pieces of a bastard file each 2¼ in. long and clamped them in place as shown. At first I tried to use a tee handle, but found it unhandy, so I ground



Valve-Seat Dresser

the bolt down to fit into a bit brace, and it worked better. The files were used for the rough cut, then disks of medium emery cloth were substituted to finish the job with. After I had faced off the metal valves, the job was satisfactory and the cost small.

W. E. CHANDLER.

Worcester, Mass.

Testing Valve for Leakage

Mr. Rae says on p. 96, Jan. 20, that the pressure dropped from 85 to 70 lb. the first day when he closed the top valve on the water glass. My opinion is that there must have been a little leakage of air or water, which would make the pressure drop. There was no leakage in the glass column, therefore the air would force the water out of the glass into the receiver until the pressures in the receiver and glass balanced. As the drop of pressure was 15 lb., all the water and some of the air would go into the receiver before equilibrium was established.

In the second tests, there was no leak to speak of in the chamber, but the air in the glass column must have escaped and the pressure in the chamber forced the water to fill the whole glass. Had the gland nut at *L* been tight in the second test, the water would have remained at its normal level, provided the chamber lost no pressure.

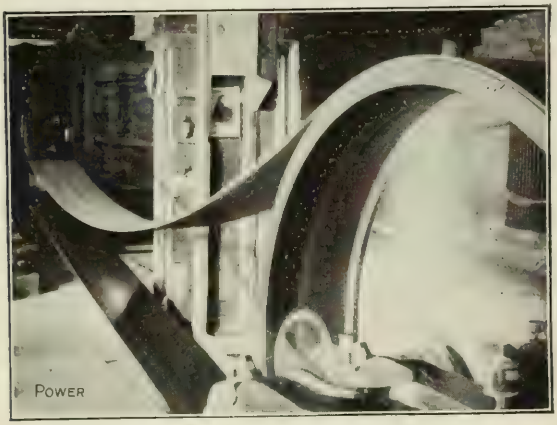
W. A. COOIL.

Ladysmith, B. C., Can.

Belt Capacity

The following rule for belt capacity has been going the rounds of the technical press:

Multiply the belt speed in feet per minute by the width in inches. The result will be the energy in watts that the belt can safely be relied upon to transmit.



A 16-IN. DOUBLE BELT TRANSMITTING 74.6 KW. RUNNING SLACK

According to this rule, a 16-in. belt, running at 3200 ft. per min., would transmit only some 51 kw. The accompanying photograph shows a double leather belt 16 in. wide, running in the plant of the Woodbury Granite Co., Bethel, Vt., between the 13-in. pulley of a Westinghouse motor which runs 900 r.p.m., to the 78-in. pulley of an air compressor, and pulling 74,600 watts (when photographed) instead of the

$$\frac{16 \times 11 \times 13.5 \times 900}{12} = 50{,}900 \textit{ watts}$$

which the rule allows. The photograph shows that the belt is carrying this load easily and with plenty of slack.

Another belt in a Canadian plant, also driving an air compressor, is carrying 61,200 watts, instead of only the 30,000 watts which the rule would allow.

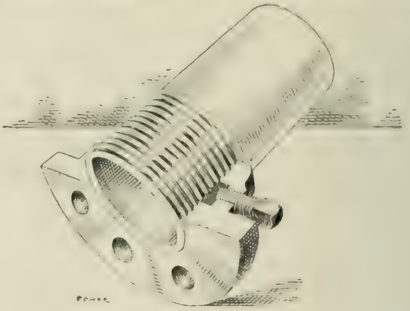
It is true that when the first belt was run tight, the tension being secured by turning up the screws in the base of the motor, it slipped and burned. But these two cases (and we can refer to numerous others) bear out our contention that a belt so treated that it can be run loose and yet have sufficient adhesion to the pulley, will give more and better service than a hard, slippery belt under excessive tension.

WILLIAM D. YOUNG.

Buffalo, N. Y. Cling-Surface Co.

Thread Leakage Prevented

Among engineers there arises discussion as to how to prevent thread leaks at the pipe end which is screwed into the hub of the flange. F. R. Maw's idea, page 932, Dec. 30 issue, is not bad, but I do not think it will answer for all uses and temperature changes, especially where the line is run outside and without covering.



LEAD FILLER

The illustration shows a flange which, when properly made, will stand a pressure of steam or boiling oil in any temperature; the flange has a recess which is filled with lead. Setscrews are provided according to the size of the flange (one, two or three), and when the pipe is screwed into it the setscrews are tightened up, so that the lead is forced into the threads with considerable pressure, making them leakproof.

J. G. KOPPEL.

Sault Ste. Marie, Ont., Canada.

[There are similar fittings on the market.—EDITOR.]

Faulty Oil-Engine Diagrams

There appears to be something wrong with R. C. Hay's diagrams, Figs. 2 and 3, in the Feb. 3 issue (herewith

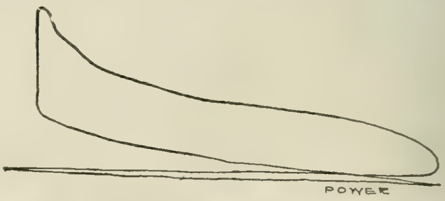


FIG. 2. DIAGRAM TAKEN BEFORE CHANGING ELBOW IN MUFFLER

reproduced). In Fig. 2 the exhaust stroke is considerably longer than the compression stroke and in Fig. 3 the exhaust stroke is shorter. This is impossible in most modern gas and gasoline engines. I can understand why Fig. 3 might have been as it is, but I cannot account for the diagram in Fig. 2. A similar diagram appears on page 241, of the Feb. 17 issue.

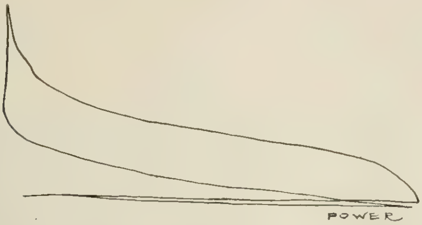


Fig. 3. Diagram after Change in Muffler

Furthermore, I cannot see why there should be a difference in the peaks and in the compression curves as Mr. Hay shows. To me, both should be either pointed, like Fig. 3, or rounded, like Fig. 2.

S. F. Wilson.

New York City.

⁂

Cause of Pound in Engine

A Corliss engine pounded badly at the crankpin, and tightening the adjusting screws or giving more or less compression had no effect. The puzzling part was that we could draw up tightly on the adjusting wedge and the bearing would not heat. At the first opportunity the bearing was taken apart and it was found that as a shoulder had formed on the back of the brass, the adjusting wedge could not be pulled up past it.

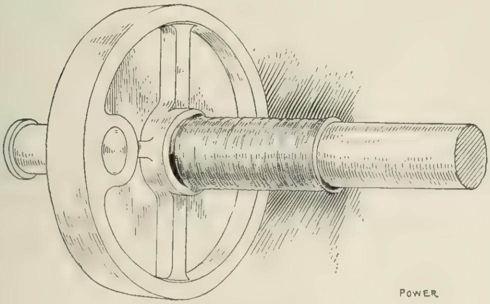
H. A. Jahnke.

Milwaukee, Wis.

⁂

Maltreatment of Apparatus

Henry W. Wetgen's article, in the Dec. 16 issue, recalls my experience while employed in a machine shop. We had to rebabbitt the quarter boxes of the main bearing of an engine. The boxes were finished and delivered, but in a short time one of the side quarter boxes was returned with orders to plane $\frac{3}{32}$ in. off the back. We were told that we had put in too much babbitt, so that the two side boxes could not be entered. As we were sure the babbitting was all right, we sent a man over. He found that no scraping had been done on any of the four boxes to make a good fit on the shaft. There also was a high point on the shaft on both ends of the bearing due to wear, as shown in the illustration. After the boxes were scraped to a good fit they were put into place without trouble.



The Journal

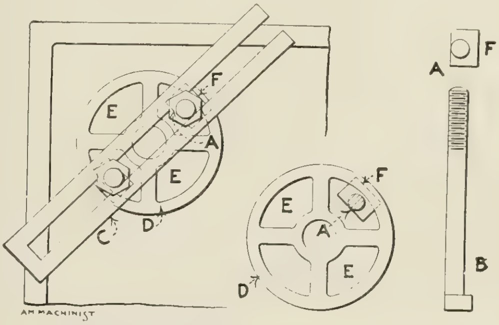
H. Jahnke.

Milwaukee, Wis.

⁂

Tool for Removing Valve Seats

Those interested may be pleased to know of a simple device for removing pump-valve seats. It requires no skill in iron working to make it, but a furnace fire, a grindstone or file, and a hammer are needed. Bend a piece of 1-in. iron U-shape, as shown. Take two bolts and file one side of each head, as shown at *A* and *B*, the diameter of the bolts to be a snug fit in the space *C*. Place the U-shaped iron over one corner of the valve chamber as at *D*. Put the bolt heads down through the ports *EE*. Let the side *F* go under the two inside rims of the valve seat. Put the nuts on the other ends of the bolts, screw them on and the valve seat will come out.



Tool for Removing Pump-Valve Seats

James E. Noble.

Toronto, Ont., Canada.

⁂

Does Graphite Influence Corrosion?

The bottom of tin buckets in which I mix boiler graphite and water, I find soon rust or corrode through. Can some reader tell why this is thus?

R. G. Lovell.

Courtland, Ariz.

⁂

Peened vs. Soldered Flanges

I disagree with F. R. Maw, page 932, Dec. 30 issue, as to his soldered joint. If there should be a slight vibration of the pipe it will tend to work the solder loose and then more calking will be necessary.

In my experience around steel and iron mills, I find that the following method is used with good results. Countersink the face side of the flange ⅛ of an inch, screw the pipe in until it comes flush with the face of the flange (if the end of the pipe should project through the flange in making it up trim it off with a chisel), and with a ball peen hammer peen the end of the pipe out until it fills the countersink all the way around. I never saw any leaky joints when put up in this way.

St. Cloud, Fla. F. M. Benjamin.

Inquiries of General Interest

Flat Compounded Generator—When is a generator said to be flat compounded?

V. S.

When its shunt and series coils are so proportioned that the voltage remains practically constant at all loads within a predetermined range.

Air Chamber on Pump Suction—What is the purpose of placing an air chamber on the suction side of a pump?

S. D. N.

To obtain an air cushion for preventing water hammer caused by sudden checking of the velocity of the suction water when the pump piston stops or reverses.

Use of Rectifying Commutators—Why are not rectifying commutators used more extensively?

A. F. M.

With heavy currents and high voltages their use is accompanied by excessive sparking at the brushes and their employment is limited to small currents at moderate voltages.

Radiation of Heat from Oily Surfaces—What is the relative loss of heat by radiation from the polished surface of a cylinder head whether oiled or dry?

C. B.

The loss of heat from polished cast-iron cylinder head is about 2½ times as much per minute when moist with oil as when wiped perfectly dry.

Draft Gage Connections Must Be Tight—Should draft gage connections be made by straight pipes or may they be made with pipe bends and elbow fittings?

I. C.

As there is no flow through the connections they may be made with bends and fittings, but for correct draft-gage indications all joints must be perfectly draft tight.

Clearance of Valve with Pressure Plate—What should the clearance be for a balanced slide valve with pressure plate?

C. S.

The clearance should be only enough to compensate for any inequalities of expansion and for that purpose the distance pieces supporting the pressure plate are usually made about two one-thousandths of an inch thicker than the valve.

Pressure on Discharge Side of Induced Draft Fan—Should not the pressure on the discharge side of the fan in an induced draft system indicate a pressure above atmosphere because of the fan forcing the gases up the stack?

J. S.

The pressure may be greater or less than that of the atmosphere depending, for the given capacity of the fan, on the temperature of the gases and the size and height of the stack.

Joints of Brine Tanks—What is the object of using tarred paper between the joints of a steel-plate brine tank and how do such joints compare with ordinary riveted joints?

S. W. N.

In erecting brine tanks tarred paper is sometimes used as packing placed between the lap of joints that are bolted together, but such joints are not as good nor as durable as hot riveted joints made tight by calking the edges of the plates.

Ratio of Heating Surface for Factory Buildings—How many cubic feet of space are usually allowed per square foot of steam pipe radiating surface for warming factory buildings

S. R.

For average winter weather requirements of the northern states, and with average brick construction of factory buildings, ordinary exposures and good distribution of radiating surfaces, it is usual to allow a ratio of 80 to 90 cu.ft. of space to one square foot of pipe radiating surface, varying according to the exposure and uses made of the rooms which are heated.

Compressibility of Water—How much would a given volume of water be compressed if subjected to a pressure of 100 lb. per sq.in.?

E. R.

The compressibility of water is from 0.00004 to 0.00005 of its original volume for a pressure of one atmosphere, decreasing with increase of temperature. Allowing average compressibility of 0.000045 of volume for a pressure of one atmosphere and one atmosphere as equivalent to 14.7 lb. per sq.in., then for 100 lb. pressure per sq.in. a given volume of water would be compressed

$$\frac{100 \times 0.000045}{14.7}$$

or about $^{1}/_{3267}$ of its original volume.

Stack Size Using Oil Fuel—In a case where a 48-in. diameter stack 90 ft. high is suitable for a 350-hp. boiler burning bituminous coal, for what increase of boiler capacity would the same stack be suitable using oil as fuel?

J. G. S.

In burning oil owing to the smaller volume of gas formed as compared with coal, the forced-draft action of oil burners and the absence of obstruction to draft by grates and a bed of solid fuel, it has been found that for the same boiler capacity a stack of about 60 per cent. capacity is sufficient when burning oil. Therefore, a stack suitable for development of 350 boiler-horsepower burning bituminous coal with natural draft should be adequate for

$$\frac{350}{0.60} = 583$$

boiler-horsepower when oil is used as fuel.

Boiler Horsepower of Steam Required for Steam Kettles—Without allowance for losses of heat by radiation or by evaporation from the surface of the water, what number of boiler-horsepower would be required for heating in steam jacketed kettles, 3000 lb. of water per hour, from 62 to 212 deg. F.?

E. C.

Each pound of water would require 212 — 62 = 150 B.t.u., and for heating 3000 lb. there would be required

$$3000 \times 150 = 450{,}000 \text{ B.t.u.}$$

As one boiler-horsepower is equivalent to the evaporation of 34½ lb. of water per hour from and at 212 deg. F., each pound requiring for the latent heat of evaporation 970.4 B.t.u., one boiler-horsepower is therefore equivalent to

$$34\tfrac{1}{2} \times 970.4 = 33{,}479 \text{ B.t.u. per hour,}$$

hence to heat 3000 lb. of water per hour under the conditions stated would require

$$450{,}000 \div 33{,}479 = 13.4 + \text{ boiler-horsepower.}$$

Horsepower per Square Inch of Indicator Diagram—When a number of indicator diagrams are of the same length and taken with the same scale of spring, how would the horsepower constant be found per square inch of area of the diagrams obtained by a planimeter?

H. J.

The mean effective pressure of a diagram being its area in square inches divided by its length in inches and multiplied by the scale of the indicator spring, or

$$\text{mean effective pressure} = \frac{a \times s}{l}$$

then in the ordinary formula

$$\text{hp.} = \frac{P \times L \times A \times N}{33{,}000}$$

by substituting the value of the mean effective pressure for P we would have

$$\text{hp.} = \frac{\dfrac{a \times s}{l} \times L \times A \times N}{33{,}000} = a \times \left(\frac{s \times L \times A \times N}{l \times 33{,}000}\right)$$

and by making a = 1, the formula becomes:

$$\text{hp. for 1 sq.in. of diagram} = \frac{S \times L \times A \times N}{l \times 33{,}000}$$

i.e., the number of horsepower per square inch of area of the diagram is found by multiplying together the scale of the indicator spring and the length of the stroke in feet by the area of the engine piston in square inches and the number of strokes per minute, and dividing by the product of the length of the diagram in inches and 33,000.

Engineers' Study Course

Curve Plotting—III

From the preceding lessons we can conclude that all quantities may be divided into two classes: *constants* and *variables.* A constant quantity is one that maintains a fixed value, for example, the length of the stroke of an engine does not change. The speed and the load may change but the stroke remains the same under all conditions. A variable is a quantity whose value is changing. Variables may be subdivided into *dependent* and *independent variables.* Thus the mean effective steam pressure in an engine cylinder is a dependent variable, for its value is determined by the load on the engine. The load on the engine is an independent variable, for it can be changed at will. (In a sense the load is a dependent variable, as it is limited by the power of the engine.)

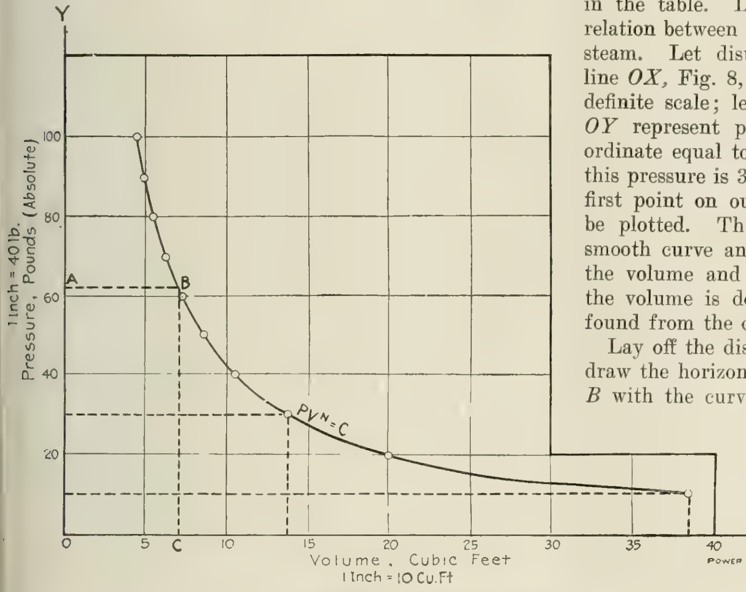


FIG. 8. PRESSURE-VOLUME CURVE

As explained in the second lesson, a physical law may be stated in the form of an algebraic equation, or it may be represented graphically by the aid of a *curve* or *graph,* and in most cases the latter method will give a clearer idea of the law of variation than will a mere setting down of the equation. Take, for example, the law of the expansion of gases which states that *the product of the absolute pressure times the volume is equal to the weight of the gas times the absolute temperature of the gas, times a constant which is dependent upon the gas.* Stated n the form of an equation there results,

$$PV = WRT$$

Assume W as unity and let T remain constant, and we have the well known *isothermal law* that *if the tempera-ure of a gas remain constant then the product of the ab-olute pressure and volume of the gas will also remain constant.* This is the approximate law for the expansion of steam in the engine cylinder.

For every pressure, saturated steam has a definite volume, and a fixed temperature. These values have been determined largely from experiment. The following table gives the values of the volume for certain pressures:

Absolute Pressure	10	20	30	40	50	60	70	80	90	100
Volume, cubic feet	38.38	20.08	13.74	10.49	8.51	7.17	6.2	5.47	4.89	4.43

Frequently the engineer desires values not given in the table and is at a loss to know how to determine them. This gives rise to another useful application of curves, namely, the determining of intermediate values not given in the table. Let us now plot the curve showing the relation between the pressure and the volume of saturated steam. Let distances (abscissas) measured along the line OX, Fig. 8, represent the volume in cubic feet to a definite scale; let distances measured along the vertical OY represent pressure, to another scale. Lay off an ordinate equal to 10 lb. From the table the volume for this pressure is 38.38 cu.ft. These two values give us the first point on our curve and similarly other points can be plotted. Through the points thus plotted draw a smooth curve and we have a graphical relation between the volume and pressure of saturated steam. Suppose the volume is desired at 62 lb. pressure. This can be found from the curve as follows:

Lay off the distance OA (to scale) to represent 62 lb., draw the horizontal line AB; at the point of intersection B with the curve drop a perpendicular BC, cutting the volume axis at C. Then the line OC multiplied by the volume scale gives the desired volume which in this case is 6.95 cu.ft.

Another instance where a knowledge of curve plotting is essential is in the testing of boilers, engines, generators, motors, etc. A mere tabulation of the data taken during the test is of little value in giving a general conception of the performance of the given unit. The following table gives the results of a series of tests on a four-cylinder four-cycle Diesel oil engine.

Test No.	1	2	3	4	5	6
Kw.	..	31	71	109	150	169
Net b.hp..............	2	50	111	163	220	246
R.p.m.	171	169	167	164	165	162
Pounds of fuel per b.hp. hour..........	..	0.77	0.48	0.45	0.44	0.444
Thermal efficiency....	..	17.4%	27.8%	29.5%	30.3%	30.2%

In Fig. 9 let distances along the axis OX represent the net brake horsepower (b.hp.) to an assumed scale. Let the ordinates along OY equal the revolutions per minute to a definite scale. From the values given in the table locate the necessary points and plot the curve AB which shows at a glance the variation in speed of the engine as the load is increased or decreased.

It is often desirable to have on the same chart a series of curves showing the relation between the dependent and the independent variables. In a commercial test the load is taken as the independent variable. In this case we will take speed, thermal efficiency and fuel consumption as the dependent variables. To plot these new curves the same abscissas (load) can be used, but new vertical scales must be assumed. At the right of Fig. 9 let distances along XY' represent thermal efficiencies in per cent. to an assumed scale—one unit on this line will necessarily mean something entirely different from one unit on the line OY. Next take the values of the efficiencies from the table corresponding to the brake loads; locate a new set of points and through them draw the curve CD. From this curve we find that the maximum efficiency occurs when the load is 220 b.hp. The curve also shows how the efficiency decreases under light loads and also on the overloads.

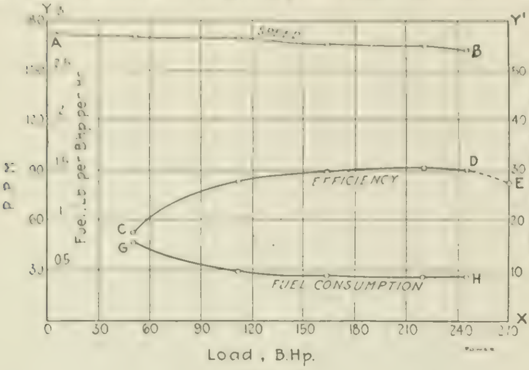


Fig. 9.

There remains the fuel-consumption curve. Here, again, a new vertical scale must be assumed and will represent pounds of fuel per brake horsepower per hour. To avoid confusion it is well to mark the values for fuel inside the line OY and keep the values of speed outside the line OY. Taking the necessary values from the table and plotting the points there results the curve GH. Still further curves might be plotted on this same chart. The student is urged to plot these same curves to different scales and compare the results.

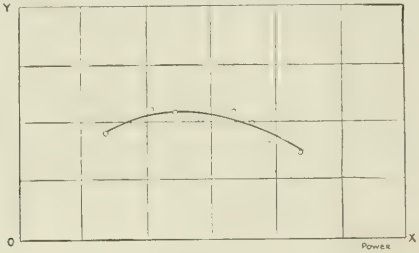


Fig. 10.

By a careful study of the curves shown in Fig. 9 predictions can be made as to the probable values under other conditions of load. Thus if the net brake horsepower were run up to 270 (provided the engine would carry such a load) the efficiency would likely drop to the point E or about 27 per cent. This value is found by extending the curve to the point E by following the general outline of the curve CD.

In plotting curves of this type great care must be taken to select suitable scales or false deductions may be drawn from the results. No definite rules can be given as to what units should be used but it is hardly probable tha we would take, say, seven or nine units per inch bu rather four or eight, or still better multiples of ten. I choosing the scales two things should be borne in mind (1) That the scales should be large enough to give th required degree of accuracy and (2) that they shoul not be so large as to separate the points of observation b great distances or to represent a degree of accurac greater than the original figures. In all such cases th scales should be clearly marked upon the axes and bot scales should start with 0 value at the origin or the in tersection of the axes of X and Y.

At times when an attempt is made to plot a curv between two variables it will be found that a smooth curv cannot be drawn that will touch or pass through all th points of observation, due, perhaps, to unavoidable ina

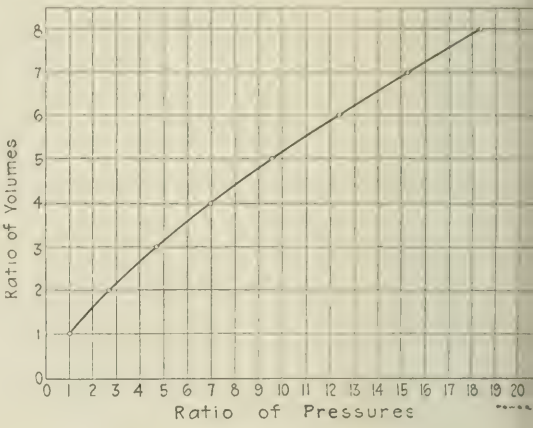


Fig. 11.

curacies in the readings. In such cases (see Fig. 10 locate all the points and mark them by a ∘ or +, an then draw a smooth curve, as shown, to touch on the av erage values or pass as near to them as possible.

As a final application let us consider the case of a ga engine. It is desired to find the probable pressure at th end of the compression stroke. The approximate law o compression is

$$PV^{1.4} = constant$$

Let the clearance volume equal V_1 and the total cylinde volume (piston displacement plus clearance) equal V Let P_1 equal the pressure at the end of compression an P_2 equal 14.7 equal the pressure at the beginning of com pression. Then

$$P_1 V_1^{1.4} = P_2 V_2^{1.4} \text{ or } \frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{1.4}$$

This makes a hard equation to solve and to facilitate com putations of this character curves are plotted giving th ratio between pressures for given volume ratios. If th clearance is $33\frac{1}{3}$ per cent. the volume ratio is then 4 an from the curve, Fig. 11 (plotted from computed data the pressure ratio is approximately seven. Therefore, th pressure at the end of compression equals

$$7 \times 14.7 = 102.9 \text{ lb. abs.} = 88.2 \text{ lb. gage.}$$

From these illustrations we see that the plotting o curves is very useful to the engineer in helping him t interpret data from tests, to predict results under othe conditions, to find intermediate values not given in table and to aid in the solution of complicated ratios.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The editor of a Michigan paper, says "Factory," apologized for its late appearance as follows:

"The Times is late this week because our gasoline engine got a cranky streak. The more we cranked it the crankier it got. We unscrewed the umbilicus and took out the trajectory. This seemed to be all right and we concluded that there might have been a leakage of the synovial fluid through the pyloric orifice into the appendix. We had a deuce of a time removing the appendix with a monkey wrench and a cold chisel. There was nothing in it. There is a pipe that runs from the engine up through the roof of the press room. We had noticed when the engine was running that this pipe said 'kapunk' every time the clapper of the engine said 'kapeet.' We examined the kapunker and found that a swallow had built a nest in it. This solved the mystery. The engine couldn't 'kapeet' because the kapunker couldn't 'kapunk.'"

⁂

Don't be too humble—everybody steps on the doormat—"Obermayer Bulletin."

True for you, Sammy, but don't be too cocky, either, for many a man has gone to the mat for just this thing.

⁂

PEACE ON EARTH AND GOOD WILL TOWARDS MAN
POWER

An Efficient Check Valve

"You don't pass this door tonight, George William. This night work is ruinin' your health."

⁂

Wonder how an engineer was appointed as a master in chancery to determine what are the rights of the Arkansas Water Co. The lawyers had better look into this. They know little or nothing of engineering, but they get nearly all the fat jobs that pay anything. No, we're mistaken. Two photographers, a printer and an insurance collector have recently civil-serviced into a municipal ferry as deckhands.

⁂

Now and again, some power-plant man's wife writes us: "For my sake, do not send the paper any more; we can't even pay our household debts. Besides, Hubby never opens it." It seems that Hubby is a fireman and gets $12 a week. Poor wife! But ding bust you, Hubby! Probably if you had opened the paper and let some of it sink into your ivory top-piece, by this time you might be an engineer—a regular fellow, with real wages.

⁂

"Spizzerwinktum"—Now don't laugh! That's a real word, according to the latest "Standard Dictionary." It's a good word, too, because it means vim, ginger, energy, and all those things, and then some.

J-M Fyro Fire Extinguisher

A simple and efficient fire extinguisher, the J-M Fyro, discharges, by means of compressed air, a liquid gas said to be 40 times as effective as water. No mechanical force is required to operate it. It is only necessary to hold it upright and turn a small valve wheel.

This little fire-fighter, which is made by the H. W. Johns-Manville Co., Madison Ave. and Forty-first St., New York City, measures but 3x15 in. It throws a spray as well as a stream; the spray can be thrown a distance of 10 ft., the stream 25 ft. The spray is most effective on small fires, which are scattered over a comparatively large area; the stream is usually best for small, concentrated fires.

The advantage of the spray is that it will cover the blaze of the average incipient fire so that all of the liquid gas volatilizes. In so doing, the gas forms a dense combustion-arresting blanket five times as heavy as air. Because of its density and weight it quickly envelops the flames, displaces the oxygen and extinguishes the fire.

As the extinguishing fluid contains no water, it is a nonconductor of electricity and can accordingly be used in electric fires without danger of short-circuits. The fluid can also be used on gasoline and electric fires. As the fluid is noncorrosive, it does not cause rust, and will not injure the skin nor harm delicate fabrics or furnishings.

⁂

Compounding Simple Reciprocating Engines

By John S. Leese

A plant of interest is that at the Bank Wood Mills, Stalybridge, Eng.

The power house contains four engines; Nos. 1 and 2 are geared to a common shaft from which one section of the mill is driven, and Nos. 3 and 4 to a shaft transmitting power to the rest of the mill. Engine No. 2 runs at high pressure to engine No. 1, forming a compound unit, and engine No. 4 runs at high pressure to engine No. 3, making a second compound unit.

All the engines are old. Engine No. 2, built in 1865, is of the true vertical type with the crankshaft above the cylinders, the head ends of which were bolted to the foundation plate. The two double-acting cylinders are 16-in. bore by 30-in. stroke, and the engine speed is 80 r.p.m. Engine No. 1 was installed in 1832, by James Watt & Co., of Soho Ironworks, Birmingham (formerly Boulton & Watt). It is an old-pattern side-lever marine engine, with two double-acting cylinders, 42-in. bore by 48-in. stroke, and having a speed of 38 r.p.m. The flywheels of both engines have toothed racks cut around their peripheries, and both are geared with wheels on one of the mill main line-shafts. Steam at 120 lb. is supplied to both cylinders of No. 2, which exhaust into a receiver from which the steam passes to both cylinders of No. 1, the receiver pressure being about 15 lb. Vacuum is maintained by a jet condenser at about 25 in.

No. 4 engine was a two-cylinder, horizontal Corliss type, with 17-in. cylinders and 30-in. stroke, running at 80 r.p.m. This machine was originally installed in 1864, but in 1892 it was practically rebuilt. Whether it had Corliss valves originally, I do not know. I was told that the only parts of the original engine which had been retained were the crankshaft, connecting-rods and flywheel. Nobody knew the name of the original makers, though it was said to have been an American machine. Engine 3 was installed in 1815 by Hick & Co., of Bolton (now Hick, Hargreaves & Co., Ltd.), and is a two-cylinder, double-acting beam engine, 50-in. bore by 81-in. stroke, running at 21 r.p.m. It is of interest in that it is provided with steam-jacketed cylinders, and has the old type of packed D-slide valves. Engine No. 4 receives steam at 120 lb., exhausts into a receiver at about 10 lb. and runs as high pressure, the beam engine working as a low-pressure side of a compound unit. The beam engine exhausts into a jet condenser maintaining 27 in. vacuum.

The mill manager said that the average coal consumption of the plant was about 3 lb. per i.hp.-hr.; not a bad economy for a lot of engines of their age and condition.

The novelty of this old plant is that in each case, two twin-cylinder engines running at different speeds and of altogether different types, run as high- and low-pressure sides of a compound unit.

⁂

Economy of Rolling Mill Reversing Engine

SYNOPSIS—The competition between steam and electric drives for mills has been a healthy stimulus to the design of steam-reversing engines for rolling mills, with the result that the economy of such engines has been greatly improved.

⁂

Improved economy for the type is shown in the results from tests of a 46 and 76 by 60-in. twin, tandem, compound, reversing engine, Fig. 1, built by the Mesta Machine Co., Pittsburgh, for the Youngstown Sheet & Tube Co. Although this engine has been briefly described in a previous article, it is desirable to give in detail those features which have made this steam economy possible.

From Fig. 2, it will be noticed that there is but one controlling lever *A*, and that it operates the relay valve which, in turn, controls both the reversing links and throttle. When the main reversing lever is in position *B* or *C*, the throttle is wide open; in position *D*, it is closed. The steam pressure and the cutoff with which the engine works are therefore so interconnected, that at light and medium-heavy loads, the operator must work with a combination of throttle and cutoff control.

While operation with cutoff is theoretically possible with any two-lever reversing engine, it would require almost superhuman attention and skill from the operator and is therefore practically impossible. Investigation

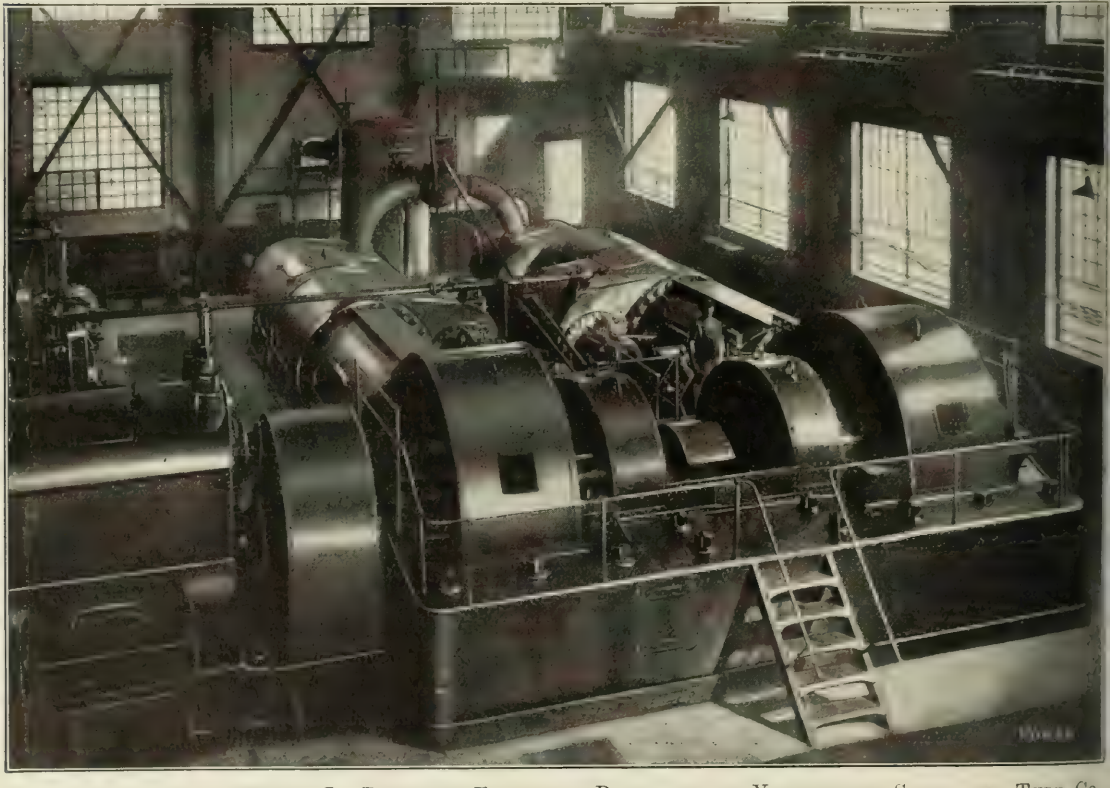


FIG. 1. MESTA 46 AND 76 BY 60-IN. REVERSING ENGINE AT PLANT OF THE YOUNGSTOWN SHEET AND TUBE CO.

shows that most operators give maximum cutoff at the beginning of the pass and then control by the throttle alone. The fact that cutoff is attained with the single-lever control is furnished by Fig. 3, which shows indicator cards selected at random from those taken during the test which is herewith described.

The opening of the throttle is not simultaneous with the movement of the reversing lever from the point *D*, for there is a certain idle stroke of the throttle valve. When the throttle opens, steam is admitted through the auxiliary ports in the bushings of the main piston valves. This combination of idle throttle-valve travel and auxiliary ports makes possible smooth and certain starting in any position of the cranks. These auxiliary ports admit steam during the regular operation of the engine—that is, during the rolling process—but while they are large enough for quick starting, they are too small to affect the shape of the regular indicator cards or the steam consumption of the engine.

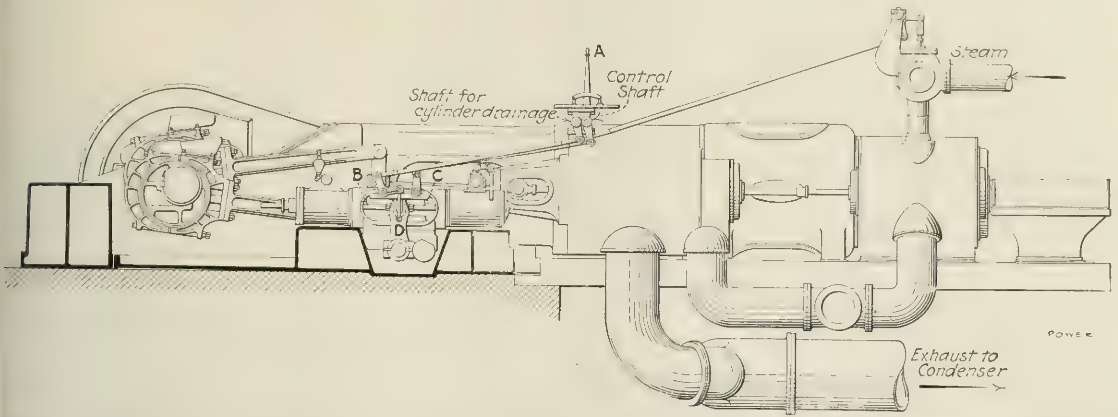


Fig. 2. Outline of 46 and 76 by 60-In. Twin Tandem Compound Reversing Engine, Showing Single Lever Control

The success of the engine depends not so much upon the mere presence of the auxiliary ports as it does upon the careful proportioning of the throw of the eccentrics, he length of the links, the size and location of the uxiliary ports and the shape of the steam ports in the ushing of the main throttle valves.

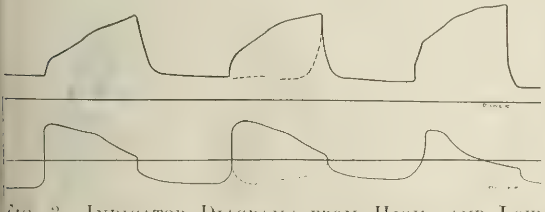


Fig. 3. Indicator Diagrams from High- and Low-Pressure Cylinders

On Nov. 28 and 29, 1913, a test was made by en-ineers of the Youngstown Sheet & Tube Co., the Carnegie Steel Co., the Mesta Machine Co., and by professors nd students of the Carnegie Institute of Technology. The est data and results were checked by all of the interested parties so that there could be no possibility of error.

The steam consumption of the engine per indicated orsepower hour was found to be between the limits of 20 and 22 lb., depending somewhat upon the method of rolling, so that 21 lb. may be taken as the average.

To make sure that the new method of control would allow sufficiently quick handling of the engine, the time for reversal was repeatedly tested. The average time of change from 60 r.p.m. in one direction to 20 r.p.m. in the other was found to be $2\frac{2}{10}$ sec. Since these speeds are ordinarily found at the end and at the beginning of the passes respectively, $2\frac{2}{10}$ sec. may be called the mean interval required by the engine for reversal. As a rule, the manipulation of the ingot takes a longer period than that required by the engine for reversal.

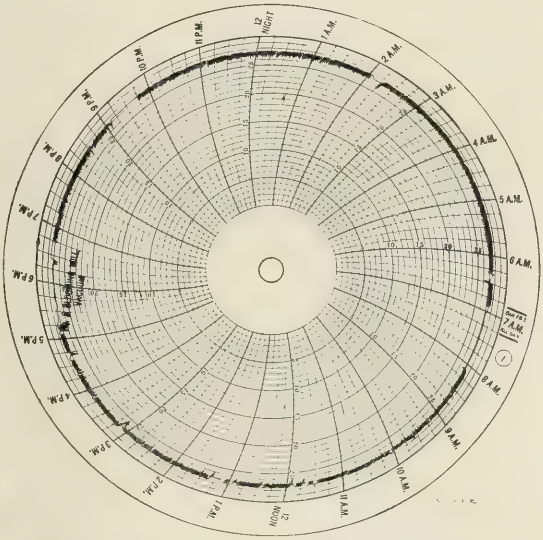


Fig. 4. Chart Showing Slight Variation in Vacuum

In connection with these test data, it may be of interest to note that obtaining them required simultaneous readings by 15 observers; eight at the continuous indicators; three on the pulpit; one for observing the temperature of the steel, two for observing the elongation of the steel, and one for taking measurements at the condenser. In addition, there was one general over-sect of the test, while the weight and the chemical composition of ingot were obtained from the mill and the laboratory. Steam engineers and rolling mill men are indebted to the Youngstown Sheet & Tube Co., for the generous manner in which it has made possible the running of such a test and for the publication of the results.

The results of this test show conclusively that the reversing engine, when correctly designed, need not fear the competition of electric drives, particularly since the remarkable economy has been attained without complication. The Mesta Machine Co. states that the engine contains fewer moving joints than the so-called standard, simple reversing engine and that consequently the cost of repairs and attendance has been correspondingly reduced. In fact, no keying up setting up, or repairing have been done on the engine since it was started in July, 1913.

Another noteworthy feature of the installation is the condenser, which was also built by the Mesta Machine Co. During the heaviest rolling, vacuum never leaves the range between 27 and 28 in. of mercury (referred to 30 in. barometer). Fig. 4 shows the vacuum in the condenser during its regular operation.

⁂

Applications of Combined Swing-Gate and Check Valve

By Oscar C. Schmidt

SYNOPSIS—Describes the various applications of the swing-gate and check valve as used in modern systems of piping.

⁂

The refinement which is taking place in power-plant equipment has spread, not only to the methods of power generation and transmission, but also to the smallest technical constructive detail connected with power-plant operation. While it is important that economy be considered in the design of any plant, it is also necessary to consider the safety details of each piece of apparatus used.

Among some of the power-plant safety devices are the safety stop, which is designed to prevent an engine from running away; the safety gage cock, which operates when the gage-glass is broken; the automatic relief valve, the check valve, and the nonreturn gate valve.

The swinging-gate and check valve is a safety device which is being used extensively to prevent disaster to the steam turbine, engine, pump, hammer, elevator and other types of steam and hydraulic apparatus. This type acts as a safety valve on any pipe line where it is necessary that the flow through the pipe shall be in one direction, and where disastrous results would follow if the medium were allowed to flow into the pump or engine cylinder in a direction contrary to the normal flow.

The extensive use of the condenser and feed-water

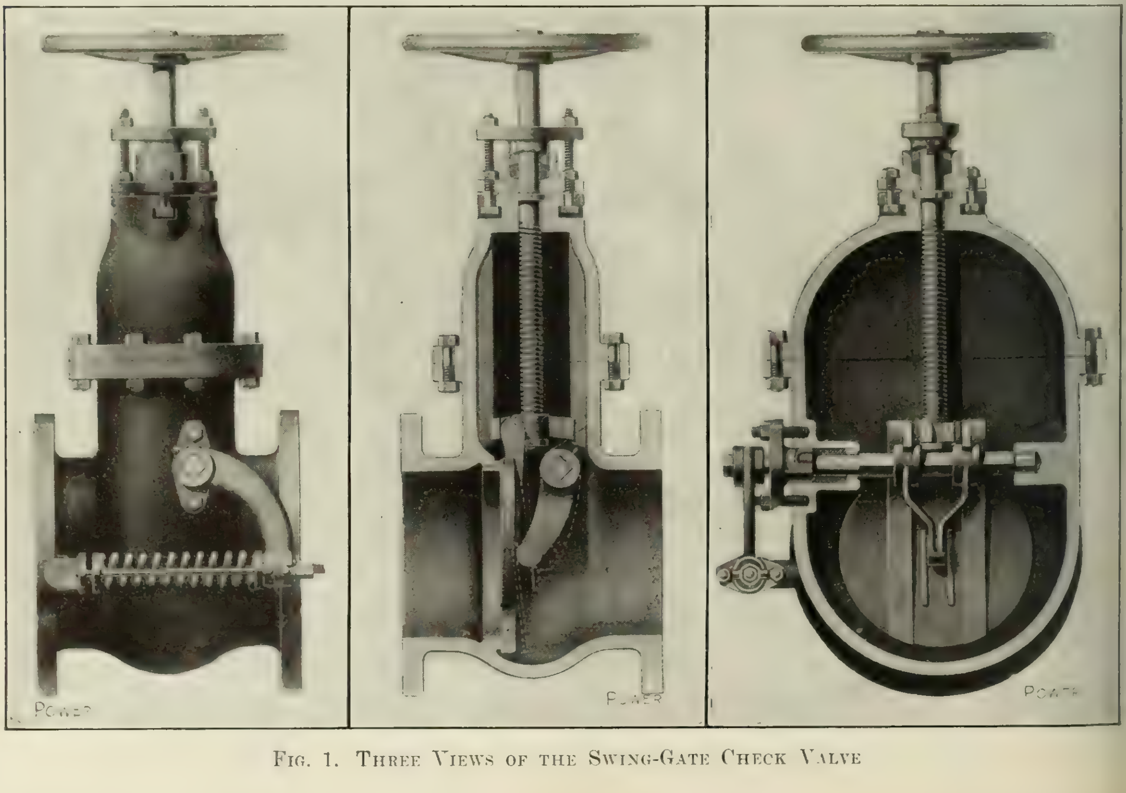


Fig. 1. Three Views of the Swing-Gate Check Valve

heater has made the connecting-pipe lines and valves matters of importance, because in the operation of a steam plant much damage can be done if the wrong valve is manipulated or the proper valves are not operated when starting and stopping.

It is also often necessary to remove from the current of the water or steam, the checking device, thus allowing continuity of flow without any restrictions which would cause back pressure or allow sediment to collect, as well as permitting the current to be reversed under pressure.

These advantages are attained by one piece of apparatus, he Nelson-Erwood swing-gate valve, Fig. 1. It embodies he features of a gate and check valve in one, and is capible of performing the functions of either. The action of he swing gate is controlled by a spring outside of the alve casing, the tension of which is regulated by the presure desired. The action of the gate valve is controlled y the handwheel, which raises the gate above the valve pening, thus giving a straightway opening, with no bstruction in the pipe. The face of the bronze gate and he seat ring are flat. The valve is positive in its action, s the gate and seat are self-cleaning by the action of raisng and lowering the gate, which will wipe or shear off ny foreign matter which would otherwise prevent its losing.

One of the interesting applications of the swing-gate valve is shown in Fig. 2. Not only do these valves permit the operation of either cylinder singly, but they also allow running cross-condensing or noncondensing. The swing-gate valve *A* protects the high-pressure cylinder; the valve *B* closes the receiver from the atmosphere; the swing-gate valve *C* acts as an automatic relief between the condenser and low-pressure cylinder, and the valve *D* prevents water from flowing from the condenser into the low-pressure cylinder. Such an arrangement guards the engine from any possible action which may be caused by negligence of operation.

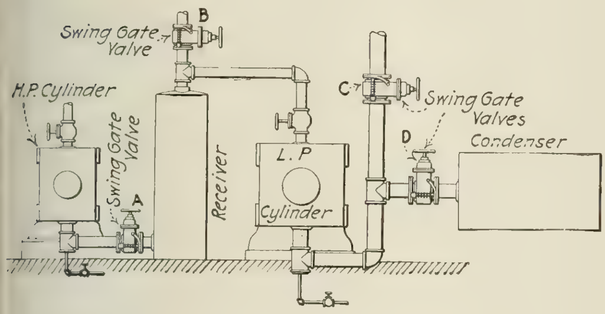


FIG. 2. METHOD OF SAFEGUARDING A COMPOUND, CONDENSING ENGINE

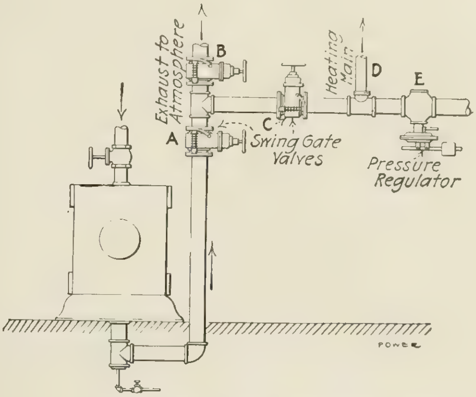


FIG. 3. HOW THE VALVE PROTECTS A NON-CONDENSING ENGINE

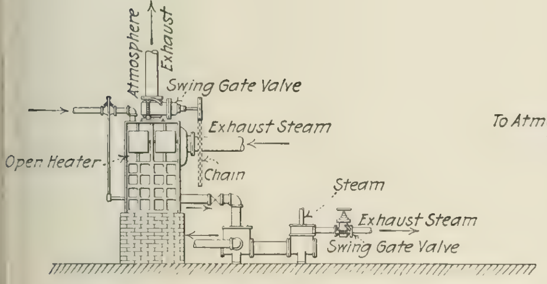


FIG. 4. SWING-GATE VALVE APPLIED TO AN OPEN HEATER

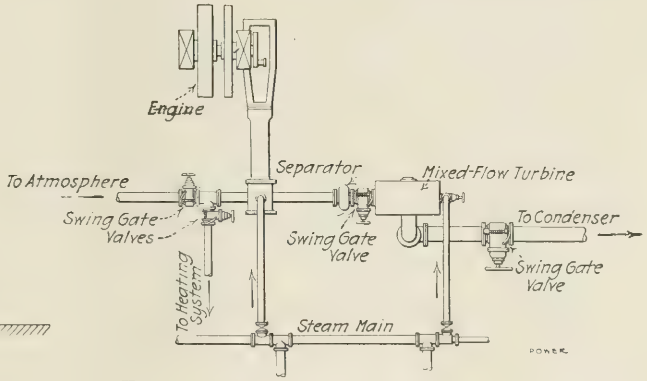


FIG. 5. APPLICATION OF THE VALVE TO A MIXED-FLOW TURBINE PLANT

When used as a back-pressure valve on an open heater or exhaust-steam system, it may be placed in any position and thrown in or out of service without changing its adjustment. The position of the swing-gate valve does not affect its operation in service. It may also be placed in any exposed position, as there are no dashpots or cushions requiring attention and no water cavities to freeze up.

The application of this safety principle to a single noncondensing engine is shown in Fig. 3. The engine is protected when the swing-gate valve *A* is closed at noon, and by the valve *C* during the night. The swing-gate valve *B* is closed against the atmosphere, and is set for the desired back pressure. When connected to a heating main *D* the swing-gate valve C is set against the pressure-regulating valve E, and prevents loss of steam through the valve E, in case the regulator does not work properly.

With a swing-gate valve on the exhaust pipe, Fig. 3, the engine can be started up with the valve closed. If the engine should be started by mistake without opening the valve, the impulse of the piston will drive the exhaust and condensation through the valve until such time as the cylinder is thoroughly warm, thus preventing any accident to the cylinder.

In these various applications to the exhaust lines of steam engines, etc., the swing-gate valve should be kept closed, as the steam apparatus can be started or stopped by opening the steam valve. Then the exhaust from one engine or pump cannot back up and flood the cylinder of another when running slowly or when stopped. This is important when several units are connected to the same line, giving freedom from accident under various operating conditions.

The swing-gate valve will prevent accidents in pump service. When cutting a pump in or out of service, it is generally necessary to close two valves on the steam side and two valves on the water side. When the swing-gate valve is installed in place of the usual valves, any pump can be readily cut in or out of service by operating the throttle valve. As the steam starts the pump, the swing-gate valves open accordingly. If the pump is to continue in operation any length of time, the swing-gate valves can be thrown out of service if desired by the operation of the handwheel, as in an ordinary gate valve.

When used with an open heater, Fig. 4, it removes any danger to the engine arising from a flooded heater. The swing valve is closed, and an engine can be started up without danger, even if the heater is flooded with cold water. Often when used with an open heater, as a back-pressure valve or atmospheric relief, it is placed on top, many feet above the operating floor; in such cases a chain wheel and chain reaching to the floor make it easy to operate.

In actual practice, engineers frequently get a call to reduce the temperature in the heating system. This can be promptly done by "cracking" the swing-gate valve off its seat with the handwheel, thus reducing the back pressure in the system, as will be shown by the back-pressure gage. As no change has been made in the spring adjustment of the valve, by closing the valve with the handwheel, the original back pressure and temperature are again restored. When used in condenser service, as in Fig. 2, it prevents any water from flowing into the engine from the condenser, although the latter may be flooded and the engine is started before the condenser vacuum has been created.

In steam-turbine practice, the swing-gate valve has particular application when low-pressure or mixed-flow turbines are used. As in Fig. 5, they are placed between the low-pressure inlet to the turbine and the engine-exhaust piping, to prevent a vacuum backing up into the exhaust piping and drawing in air through leaks and the piston-rod and valve-stem packings. The swing-gate valve is so set that whenever the pressure in the engine-exhaust piping falls below 1 lb. above the atmosphere, it closes and remains so until the pressure rises above this point. In all applications the valve can be placed in any position, the spring action controlling the pressure at which it is desired to operate the valve.

Standardization of Flanged Fittings

A notable gathering took place on Saturday, March 7, 1914, which it is confidently believed will result in the adoption of a Schedule of Standard Weight and Extra Heavy Flanged Fittings and Flanges, and its universal acceptance by all parties interested in the matter.

On the invitation of the National Association of Master Steam and Hot Water Fitters there assembled at the Hotel Raleigh, in Washington, D. C., representatives of the American Society of Mechanical Engineers, American Society of Heating and Ventilating Engineers, American Water Works Association, New England Water Works Association, Associated Factory Mutual Fire Insurance Companies, Underwriters' Laboratories, Inc., Committee of Manufacturers on Standardization of Fittings and Valves and representatives of certain departments of the United States Government.

All differences between "The 1912 U. S. Standard," issued some two years ago by the American Society of Mechanical Engineers, the National Association of Master Steam and Hot Water Fitters and the American Society of Heating and Ventilating Engineers, and the "American" Schedule, issued by the Manufacturers' Committee, were taken up seriatim and fully and frankly discussed. It was found possible to finally adjust nearly all of these differences by unanimous consent. On the most important and radical difference between the two schedules, the elimination of the short body fitting, a vote by societies showed five in favor of such elimination, one opposed and one neutral.

It was arranged that the Committees of the American Society of Mechanical Engineers, the National Association of Master Steam and Hot Water Fitters and the Manufacturers' Committee shall meet, and within sixty days put into concrete form the decisions of the conference in the production of a schedule which shall meet with the favor and acceptance of all concerned.

The conference was presided over by Dr. S. W. Stratton, Director of the Bureau of Standards, of the United States Government, whose very able and fair rulings were of great assistance in arriving at definite results.

An Ordinance

Creating the office of boiler inspector of the city of Reading, Penn., providing for the licensing of all persons having charge of or operating a steam boiler or steam engine over 10 hp. in the city, and fixing the salary and term of office of such inspector.

SECTION 1. BE IT ORDAINED BY THE COUNCIL OF THE CITY OF READING: That the office of boiler inspector be and is hereby created whose duty it shall be to issue a license to any applicant therefor who has charge of or operates a steam boiler or steam engine over 10 hp. in the city of Reading, in accordance with the provisions of the Act of Assembly approved Apr. 4, 1905, P. L. 102, and the amendments or supplements thereto.

SECTION 2. That no person shall have charge of or operate a steam boiler or steam engine over 10 hp. in the city of Reading, except locomotive boilers used in transportation and steam engine and steam boilers carrying less than 15 lb. pressure per square inch, unless such person shall, on or before Feb. 1, 1914, apply to the boiler inspector of the city of Reading for a license, who shall upon a proper examination of the applicant, and the compliance by such applicant with the provisions of the Act of Assembly of Apr. 4, 1905, aforesaid, grant him a license for the term fixed by said act.

SECTION 3. That Council shall appoint on the first day of January, 1914, or as soon thereafter as may be practicable, a suitable and competent person as boiler inspector whose term of office shall be for a period of two years from said date and whose successor shall be elected on or before the first day of January of each even numbered year for a term of two years.

SECTION 4. That the salary of the said boiler inspector is fixed at the sum of fifteen hundred dollars per annum, to be paid semimonthly as the salaries of other city officials are paid and before assuming the duties of his office he shall give a bond with surety to be approved by council in the sum of three thousand dollars for the faithful performance of the duties of his office.

(Passed Council. Dec. 24. 1913.)
(Signed) IRA W. STRATTON, Mayor.
Attest: CHARLES MARKS, City Clerk.

24,000-Hp. Hydro-Electric Development Started

For three minutes Monday evening, February 16, the city of Augusta, Ga., was in darkness. When the lights of the city flashed on again, at the touch of a switch on a platform erected for the occasion in the center of the business section, it marked the passing of the old steam-made electrical supply for the homes and industries in Augusta, and the surrounding country.

Big plans had been made to celebrate the opening of the hydro-electric power plant on the Savannah River nine miles above the city of Augusta where a dam 2000 ft. long and 27 ft. high, that holds back a pond with a surface area of 4000 acres, has been completed. There were speeches in the evening in front of one of the city's finest monuments by Governor Slaton, of Georgia, and municipal officials, members of the Merchants & Manufacturers Association of Augusta and representatives of the J. G. White Engineering Corporation of New York, which has done the designing, engineering and construction work on the new project.

The day itself was a busy one. In the morning the visiting guests and prominent citizens of Augusta took a trip to the site of the dam and power house at the invitation of the Augusta-Aiken Railway and Electric Corporation. The party had an opportunity to inspect the dam and the power house from which power will be carried down to the city of Augusta. This power will be transmitted at 44,000 volts on a great span of wires across the Savannah River to feed power to additional mills and industries in South Carolina.

A great barbecue was arranged at Stevens Creek—served in the old Georgia style, after which the party returned to the city for the evening's formal opening to be followed by a banquet.

The opening of this development marks the beginning of a new era of industrial development of this section of the South.

NEW PUBLICATIONS

TRANSFORMER PRACTICE. By William T. Taylor. Second edition. Published by the McGraw-Hill Book Co., New York. Size, 6x9 in.; 271 pages, illustrated. Price, $2.50, net.

This book represents one of the few successful attempts to cover the subject of transformer practice with a view to meeting the needs of the man installing and operating transformers. Hence, outside of the fundamental principles and equations, little space is devoted to design, except such general statements as will enable engineers to provide for the proper installation of transformers.

Various combinations are described for obtaining different voltages, as well as directions for connecting up, phasing out, etc. Operating difficulties are also taken up and the solutions pointed out. Especially useful in this respect are the suggestions for helping operators to secure the necessary service, by temporary arrangements, when short of the right apparatus.

Space is devoted to constant-current and series transformers and regulators, and several chapters cover methods of installation, cooling, drying out, grounding and practical testing of transformers, concluding with transformer specifications.

The new edition of the Simplex Manual, published by the Simplex Wire & Cable Co., of Boston, is ready for distribution (free) to anyone who asks for it. The 92 pages are full of tables and other information pertaining to insulated conductors and other electrical matters.

Civil-Service Opportunities

COMPETITIVE EXAMINATIONS *for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commissions Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.*

Engineer and Fireman—The New York State Civil Service Commission will hold an examination for the position of engineer and fireman of the Rensselaer County Court House, Mar. 28, 1914. Salary, $1000 a year. Residents of the county will be preferred in the appointment. Applicants should have had practical experience in the operation of steam plants. Applications must be filed on or before Mar. 20. Address the State Civil Service Commission, Albany, N. Y.

Sanitary Engineer—The United States Civil Service Commission will hold an examination, Apr. 6, 1914, for this position in the Public Health Service. Salaries, $2000 to $2500 per year. Duties: To engage in research work in connection with field investigations of stream pollution, water purification and the treatment and disposal of sewage and industrial wastes. Subjects: General education and technical training; technical and professional experience and fitness; publications or thesis. Applicants must be between 25 and 35 years old, college graduates in a scientific course, or the equivalent, have had two years' laboratory and field experience and preferably know French and German. Address the United States Civil Service Commission, Washington, D. C.

ENGINEERING AFFAIRS

When you get six such stars as John F. Sparrow, Engineer of the New York Edison Co., New York, I. E. Moultrop and James B. Andrew, of the Edison Electric Illuminating Co., of Boston, J. W. Parker, of the Detroit Edison Co., John Hunter, of the Union Electric Light & Power Co., of St. Louis, and W. L. Abbott, of the Commonwealth-Edison Co., to discuss Large Steam Power Plants, there is bound to be something interesting brought out, and this is the program for the third dinner meeting of the Chicago section of the American Society of Mechanical Engineers. The meeting will take place in the Crystal Room of the Sherman House on Wednesday, Mar. 18, at 6:30. Paul P. Bird, of 120 West Adams St., is the Chairman of the section, and C. W. Naylor, 121 North State St., Secretary.

About 250 of the local members of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers and the Boston Society of Civil Engineers held their fifth annual banquet at the Boston City Club in Boston, Mass., Mar. 4, 1914. The speakers were Guy E. Tripp, of the Westinghouse Electric & Manufacturing Co., who considered some of the good and bad features of pending national legislation concerning the control and regulation of business; Dr. A. E. Kennelly, Harvard University, who discussed some of the good work which has been accomplished by the International Electrotechnical Commission toward bringing about uniformity of electrical standards and nomenclature; C. O. Mailloux, president of the American Institute of Electrical Engineers; James Hartness, president of the American Society of Mechanical Engineers, and Dr. M. W. Franklin, of the Sprague Electric Works of the General Electric Co. Prof. H. E. Clifford, Harvard University, acted as toastmaster. The arrangements were in the hands of a committee headed by N. J. Neale, chairman.

Something over three-quarters of the space has already been contracted for at the Power Show, to be held in Boston, Mass., Apr. 27 to May 2, under the auspices of the New England Association of Commercial Engineers in connection with the Fourth National Textile Exhibition, to be held in the Mechanics' Building, under the auspices of the Textile Exhibitors' Association. Among those who have made reservations are:

Albany Lubricating Co.; American Steam Gauge & Valve Manufacturing Co.; Ames, B. L.; Anderson, V. D.; Ashton Valve Co., The; Bowser & Co., Inc., S. F.; Buckeye Engine Co.; Chesterton Co., A. W.; Cling-Surface Co.; Dearborn Chemical Co.; Fairbanks Co., The; Foster & Sons Co., F. W.; Garlock Packing Co., General Electric Co.; Graton & Knight Manufacturing Co., Griscom-Russell Co.; Harrison Safety Boiler Works; Hill Publishing Co. ("Power"); Ingersoll-Rand Co., Jenkins Brothers, Keystone Lubricating Co.; Lagonda Manufacturing Co.; Lunkenheimer Co.; Mason Regulator Co.; McClave-Brooks Co.; McLeod & Henry Co.; Nashua Machine Co.; "National Engineer"; National Tube Co.; Roto Co., The; Warren-Webster & Co.; Westinghouse Electric & Manufacturing Co.

Those desiring space who have not yet arranged for it are urged to do so without delay as there is certain to be insufficient to accommodate all.

Wednesday evening, Mar. 18, will be observed as Visitors' night in the School of Science and Technology of Pratt Institute, Brooklyn, N. Y. From eight to nine o'clock all its shops, laboratories and drawing rooms will be open to the public. All persons interested in industrial education will be given an opportunity not only of viewing the students at work in the various courses, but also of inspecting both the results and methods as well as the equipment and general facilities of the Institute for conducting this kind of industrial training. The School of Science and Technology provides instruction in industrial electricity, technical chemistry, mechanical drawing and machine design, strength of materials, stationary engineering and power-plant machinery, machine work and tool making, carpentry and building, pattern making, sheet-metal work, plumbing and trade teaching for the training of skilled workmen who desire to prepare themselves for teaching their trades. Practically all of the thousand students in the evening classes are men who are regularly employed in their several vocations, and who use these courses as a means to prepare themselves for more efficient service.

The New England Society of Superintending Engineers held its regular monthly meeting and dinner at the American House, Boston, on the evening of Feb. 26, at which the following newly elected officers were installed: President, L. H. Brown, chief engineer, Bay State Street Ry. Co., Lynn, Mass.; vice president, Thomas Armstrong, chief engineer, Boston Safe Deposit & Trust Co., Boston; secretary, Stephen Barnaby, chief engineer, Copley Plaza Hotel, Boston. The installation was conducted by Past President George W. Walsh. The speaker of the evening was Mr. Leach, Boston manager of the American Engineering Co., who gave an illustrated lecture on automatic stokers and the smokeless combustion of fuel, and F. L. Fairbanks, chief engineer of the Quincy Market Cold Storage Co., also gave an illustrated lecture on the efficiency of multistage centrifugal pumps.

PERSONALS

F. A. Saylor has been put in charge of the Indianapolis territory of the C. & C. Electric & Manufacturing Co., Garwood, N. J.

Henry Madison has been appointed chief electrician of the new municipal lighting plant at Franklin, N. J. Mr. Madison was formerly with the Newton Gas & Electric Co., Newton, N. J.

J. B. Anderson, for many years engineer of power stations of the Savannah (Ga.) Electric Co., has been transferred to the Baton Rouge (La.) Electric Co. He became superintendent of lighting in Baton Rouge on March 1.

Sir William Willcocks, the famous English engineer, who is known as the builder of the Assuan Dam across the Nile, will make his first visit to the United States in April to attend the fourth annual meeting of the National Drainage Congress at Savannah, Ga., where he will deliver an illustrated address on "River Regulation and Control in Antiquity."

T. E. Keegan has been appointed assistant manager of the Tyler Underground Heating System, Pittsburgh, Penn. Mr. Keegan is said to be one of the best posted heating men in the United States. He was with the Atlas Engine Co. and the American Stoker Co., with the Consolidated Engineering Co., Chicago, for nine years, and the last two years was with the Open Coil Heater & Purifier Co.

OBITUARY

PROF. EDWIN J. HOUSTON

Prof. Edwin J. Houston, who with Prof. Elihu Thomson, invented the first successful arc-lighting system, died of heart disease at his home, Philadelphia, Mar. 1. He was born in Alexandria, Va., July 9, 1847.

He was educated in the public schools of Philadelphia, and later served the Central High School of that city as professor of physical geography and natural philosophy and previous to this occupied the chair of civil engineering. In 1879 he and Professor Thomson began electrical experiments and later developed the Thomson-Houston dynamo, the arc-lighting system bearing their names and other inventions. Professor Houston wrote many books on electrical and scientific subjects, and devoted considerable time to lecturing.

From 1893 to 1895 Professor Houston was president of the American Institute of Electrical Engineers. He was a member of the American Institute of Mining Engineers, the New York Electrical Society, the American Philosophical Society, the Electrotherapeutic Society, the American Historical Society and other organizations.

He was unmarried and is survived by a brother and two sisters.

COLUMBUS DILL

Columbus Dill was born in Tully, N. Y., Aug. 12, 1840, and died at his home, 99 St. James Ave., Boston, Mar. 4, 1914.

At 12 years of age he started on a sea-faring life with his uncle, serving as cabin boy on one of the trade vessels of the Weld Line, which were at that time plying between Boston and various foreign ports. He rapidly worked up to the position of chief officer, in which capacity he served on such boats as the "Rainbow" and the "William H. Thorndike."

In 1876 he left the sea, and took up stationary engineering as a profession, being employed as an engineer for about a year at the Perkins Institute for the Blind at South Boston, afterward going with the National Tube Works, then at East Boston, where he served as chief engineer for several years.

He next took a position with John Post, Jr., & Co., of Boston, handling their injector business, after which he became connected with the Common Sense Metallic Packing Co., as a traveling salesman.

From 1889 until the time of his death he was connected with the Ashton Valve Co., of Boston. He traveled extensively while in this business, going as far West as Kansas City and South to New Orleans, giving special attention to power plant work, and to the stationary engineers operating them, among whom he had a host of friends and acquaintances.

He was a charter member of the National Association of Stationary Engineers, No. 1, of Boston, and was elected as delegate to represent this association to the national conventions for many years. He also served as United States deputy of the N. A. S. E. for many years, which position he held at the time of his death.

Columbus Dill

He was a member of the E. P. Carpenter Post No. 91, G. A. R., several Masonic bodies, the Engineers' Blue Room Club, of Boston, and the New England Association of Commercial Engineers.

For the past two years he was not very active, although his health was fairly good up to within three days of his death when he was taken with an attack of indigestion, which suddenly and wholly unexpectedly terminated with apoplexy. His funeral services, held Mar. 6, were attended by many of his engineer friends and business acquaintances.

He leaves a widow, who usually accompanied him, of late years, on his extended trips, and who has been an active worker in the Ladies Auxiliary of the N. A. S. E. and in the order of the Eastern Star.

Mr. Dill was probably one of the best known travelers among engineers in this country, and was always exceptionally prominent and influential at the national conventions of the N. A. S. E. He was zealous and untiring in business, and had a kind-hearted and genial disposition, which easily won friends, and an uprightness of character that was beyond reproach.

POWER

Vol. 39 NEW YORK, MARCH 24, 1914 No. 12

They Also Serve

DON'T WITHHOLD THE CREDIT THESE CHAPS DESERVE

When we are pitying ourselves for all the hardships we have to undergo in this trying winter weather to keep the "juice" in the line so that others can get to their homes and there enjoy light and comfort, let us not forget that there are others who suffer and sacrifice for the public weal in still humbler positions.

And, another thought! If these horses could talk, wouldn't they say, "Do make this load last as long as you can?" Coal economy has its humanitarian element, also; at times.

Continental Motor Mfg. Co.'s Power Plant

By Harry C. Spillman

SYNOPSIS—A 900-kv.-a. capacity plant containing features not generally found in a plant of its size. Vertical boilers supply steam to two engines. Coal is handled by a monorail grab-bucket system. The finish of the engine room is out of the ordinary.

*

The new power plant of the Continental Motor Manufacturing Co., Detroit, Mich., has a number of interesting features for a plant of 900 kv.-a. capacity. Every detail has been carefully worked out to make the plant economical in operation and attractive in appearance. The architecture of the building, Fig. 1, was given considerable thought and it is, figuratively speaking, built around the equipment. The building is made fireproof by structural steel framework encased in masonry, steel sashes, reinforced concrete and tile floors and a concrete roof supported on I-beams. It is flooded with daylight by large windows reaching nearly to the roof which can be opened and closed with sash operators. The exterior is made attractive by using pressed brick and the clever introduction of cement-plaster panels worked in the masonry.

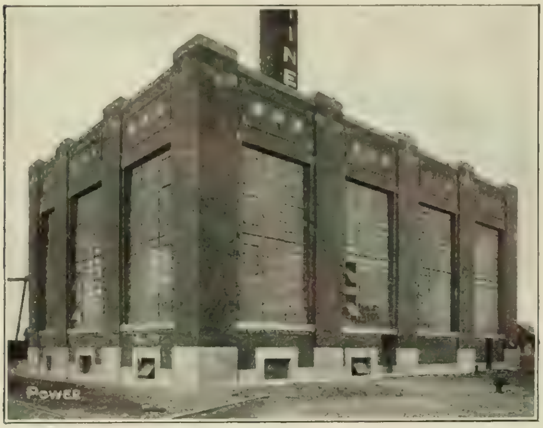


Fig. 1. Exterior of the Power Plant

The 150-ft. stack is designed to take care of the future growth of the plant, having an internal flue 8 ft. 6 in. in diameter. It is of reinforced concrete with an exterior and interior facing of dark-brown glazed tile capable of withstanding 1200 deg. F. without cracking, and has a cast-iron cap. This style of chimney has all the advantages of the reinforced-concrete stack with the attractive features of a tile chimney. The word "Continental" is laid in white enamel tile which project 1 in. beyond the face of the stack; this projection allows the rain to strike the letters and keep them clean.

Boiler Room

There are three vertical water-tube boilers, each having 2500 sq.ft. of heating surface, and steam is generated at 150 lb. Each boiler is equipped with a mechanical stoker designed to burn bituminous nut, pea and slack coal. A soot blower is also attached to each boiler for cleaning boiler tubes.

Two 10 and 6 by 12-in. steam-driven, duplex, outside center-packed plunger pumps designed for 250 lb. working pressure supply the boiler-feed water. Each pump is fitted with a force-feed cylinder lubricator, and the pumps discharge into a 6-in. feed line with feed valves located at a central point.

Coal is handled by a cab-operated, monorail conveyor, and single-rope grab bucket with a capacity of 1200 lb. of coal; see Fig. 2. The runway continues for 22 ft. beyond the power house and is supported on a trestle which spans the railroad siding. This allows the monorail conveyor to unload the cars and either store the coal in the yard or deposit it in the metal bins over the boilers. A switch on the monorail track permits the same conveyor to take care of the ashes, which the fireman pulls into the large pits located in front of the boilers.

Piping

All piping was designed with ample allowance for expansion and future extension of the plant. The accessibility of the valves and all fittings was given careful thought and special iron gratings are installed wherever necessary to carry out this scheme. Metal gratings with ladders are also installed around the water columns of the boilers.

The steam header is supported from the fire wall near the top of the boilers and runs the length of the boiler room. The ends turn down into the basement where they connect, making a loop system. Valves are placed at intervals in the header, which allows any section to be shut off for repairs without interfering with the operation of the plant. The branch lines for the engine room are taken from the header in the basement. This makes a flexible arrangement and the steam loop can be easily extended with the growth of the plant.

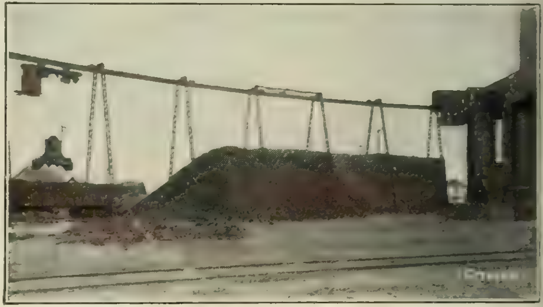


Fig. 2. Monorail Coal Conveyor

All drip pipes are connected to steam traps which discharge into a feed-water heater placed near the stack in the boiler room. The exhaust from the two engines and auxiliary equipment leads into a 24-in. exhaust line. One 12-in. branch is connected to the 1500-hp. feed-water heater and the 16-in. branch feeds the vacuum-heating system. The blowoff piping is also located in the basement with the extension stems on the valves projecting through the boiler-room floor.

As indicated by Fig. 3, the engine room is free from piping, wires, pumps and other auxiliary equipment. It contains only the generating units, exciters and switchboard. The floor is covered with 6x9-in. red quarry tile laid in white mortar and the side walls are wainscoated with white enamel brick 6 ft. high, with pale-yellow pressed brick above. The engine pits are lined with 3- and 6-in. white bathroom tile and the sub-bases of the engine above the floor line are covered with 3x6-in. red tile laid with tight joints. The railings are of steel tubing enameled black with polished brass fittings, and the equipment is painted a light pearl gray to harmonize with the surroundings.

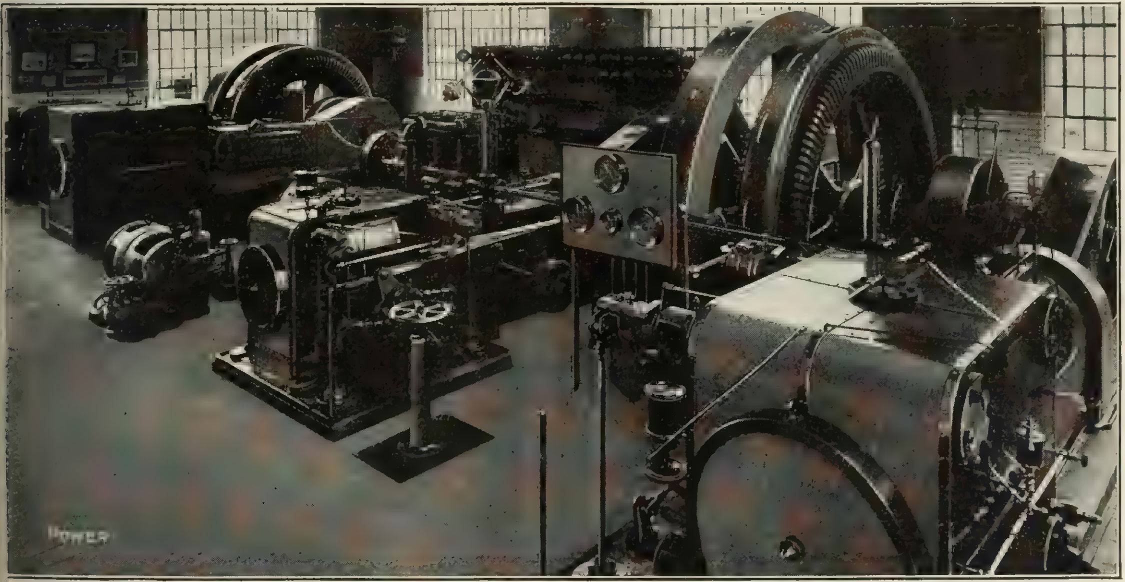


Fig. 3. General View of the Engine Room, Showing Absence of Piping

Unit No. 1 is a 20 and 30 by 36-in. cross-compound, heavy-duty Corliss engine, running at 120 r.p.m., directly nnected to a 500-kv.-a. generator. Unit No. 2 is a and 20 by 27-in. horizontal, side-crank, cross-comund engine directly connected to a 400-kv.-a. generator nning at 150 r.p.m., and is equipped with nonreleasing ulti-ported Corliss valves. Both generators are threease, 60-cycle, 240-volt, alternating-current machines d are guaranteed to carry a 50 per cent. continuous erload without injury.

Excitation is maintained by a 25-kw., 125-volt, directnnected, turbo-generator unit, running at 3500 r.p.m. is used for starting only and after the main units are operation the excitation is thrown onto a 125-volt tor-generator set, of 40 kw. capacity This exciter also rnishes the necessary direct current for the magnetic ucks and storage batteries in the factory.

Both engines are furnished with a continuous supply oil from a gravity-oiling system which filters the oil l automatically returns it to a gravity tank by means a small steam pump.

The engine-room floor is spanned by a 15-ton hand-power traveling crane, having a 25-ft. lift and a two-speed hoist and automatic brake. Cables are used on this crane instead of chains.

Switchboard

The leads connecting the generators to the switchboard are made up of ¼x4-in. laminated copper bars covered with tape and supported on brackets. Each generator panel has an alternating-current ammeter in each phase, a voltmeter with a three-point switch, one indicating wattmeter, a direct-current ammeter for the field circuit, and a recording wattmeter, besides the necessary switches.

Two panels are given up to the power feeders; each building having a separate circuit for power which is protected by a three-pole, double-coil, circuit-breaker, nonclosable on overloads.

The lighting circuits are located on the end panel. Each circuit has a three-pole, single-throw switch with a fuse panel on the rear of the board. By means of balance coils, 110-volt, single-phase current is used for illumination. The exciter panel carries a direct-current voltmeter with a plug switch, two direct-current ammeters and the necessary switches.

The plant is illuminated with Cooper-Hewitt lamps having red reflectors which changes the green rays to a lighter shade and makes an excellent illumination. Floor and wall outlets are scattered throughout the plant, allowing the use of extension lamps when making repairs.

The entire equipment was purchased under high efficiency guarantees. The stokers and boilers are covered with a guarantee to evaporate 10 lb. of water from and at 212 deg. F., with bituminous nut, pea and slack coal containing not less than 13,500 B.t.u. nor more than 8 per cent. ash. The Corliss engine has a guarantee that the steam consumption will not exceed 20 lb. per i.hp when operating at full load. The other engine is guaranteed to work at full load with a steam consumption not exceeding 17.9 lb. per i.hp. Both generators show an efficiency of 94.5 per cent. at full load.

Engine-Turbine Units or Straight Turbines

By Charles H. Bromley

SYNOPSIS—An interview in which Mr. Stott tells which class of prime mover—high-pressure turbine or reciprocating engine-low-pressure turbine—would be more economical in a new plant. Why low-pressure turbines were installed in the 59th Street Station and high-pressure turbines were selected to displace the reciprocating engines at the 74th Street Station.

⁂

Since the installation of the low-pressure turbines connected to the 7500-kw. angle compound engine at the 59th Street Station of the Interborough Rapid Transit Company, of New York, much interest, both here and abroad, has centered in these combined units. It is the high economy of these prime movers that has excited interest. The fuel consumption per kw.-hr. of the combined unit is less than 2 lb. of coal having 14,500 B.t.u. The installation and remarkable results obtained at this station, and the knowledge that reciprocating engines were to be scrapped to make way for three 30,000-kw. high-pressure turbines at the 74th Street Station of the same company, has caused many to inquire: Why, with the extraordinary results obtained with the combined units at the 59th Street Station, were complete expansion or high-pressure turbines selected for the 74th Street Station? What would be the more economical unit to install in a new plant, combined engine-low-pressure turbine, or a high-pressure turbine?

In a paper on the selection of prime movers, read befor the joint meeting of the New York members of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Electrochemical Society, H. E. Longwell, referring to Henry G. Stott, superintendent of motive power of the Interborough Rapid Transit Co., said: "If Mr. Stott would be willing to say whether or not in an absolutely new plant he would seriously contemplate the installation of combination reciprocating engines and low-pressure turbines, such a pronouncement would be far more convincing than volumes of arguments based purely on theoretical grounds."

With these questions in mind, I asked Mr. Stott to express, through POWER, the opinion for which Mr. Longwell wished; and to explain the considerations which had led to the failure to repeat at 74th St., the course which had been so successful at 59th St.

Mr. Stott says that a complete expansion turbine will prove most economical for a new plant because its first cost is much lower than that of a reciprocating engine-low-pressure turbine unit, and because the maintenance and operating charges are less. Complete expansion turbines (turbine and generator combined) of large power —20,000 kw. or so—may be purchased for $8 per kw., the price increasing as the capacity of the unit becomes less. Combination reciprocating engine-low-pressure turbine units of large power will cost in the neighborhood of $40 per kw. The interest on the capital invested is, therefore, considerably higher in the case of the latter kind of unit. Obviously, the cost of attendance, supplies and maintenance will also be greater.

The steam consumption of the combined units at 59th Street Station is about 14.2 lb. per kw.-hr., and during the test[*] reported by Mr. Stott, the overall efficiency, as shown by one test, was 72½ per cent. of the total available energy between the steam entering the engine and the recorded exhaust pressure of the turbine. This was an improvement in economy of 13 per cent. over the best high-pressure turbine results obtained at that time (1909). In this connection, the prediction of O. Junggren, turbine engineer of the General Electric Company, in commenting on Mr. Stott's paper, that "a high-pressure turbine would be considerably cheaper than the combined unit, and, in the near future, high-pressure turbines will be made having as high efficiency as the combined unit and still be cheaper than a combination of engine and turbine" is interesting.

Mr. Junggren knew what he was talking about, for the guaranteed steam consumption of the 30,000-kw. turbines for the 74th Street Station is 11 lb. per kw.-hr. at 150 deg. F. superheat. Such an increase in economy of the high-pressure turbine compared to that obtained with such units contemporaneous with the installation of the low-pressure turbines at 59th Street has occurred, that the question of which kind of unit would be best to install in a new plant is no longer a question. The complete expansion turbine has the advantage, as Mr. Stott says, of a much lower first cost combined with lower maintenance and operating costs. So much for the selection of a prime mover for a new plant.

As far back as 1908, the rapidly increasing traffic in the subway made necessary much additional power to be available during the winter of 1909-10. Space admitted installing three high-pressure turbines, each with a capacity (7500 kw. maximum) equal to that of each engine, or of connecting a low-pressure turbine to each of the nine engines. So space or real estate values were not determining factors in the selection of prime movers to meet this increased demand. The saving in investment, made possible by using the reciprocating engines, was the chief determining factor. These engines were in excellent physical condition. They were designed for 200 lb. pressure, and the 42-in. horizontal high-pressure cylinders are provided with poppet valves which are capable of handling high pressure and temperature without distortion. With these valves, the steam leakage is less, and there are fewer lubrication troubles than with large Corliss valves. The high initial pressure and the ability of the engine to successfully use it, made the low-pressure turbine inevitable for this station, considering the saving on the capital invested to secure the increased capacity.

All this is not true of the 74th Street Station. The engines were designed for an initial pressure of only 160 lb. All of the cylinders have Corliss valves, which are very large and subject to the troubles mentioned. The engines are in a much less perfect physical condition than those at 59th Street. Space is valuable and limited at the 74th Street Station, and the needed increase in capacity is such that a low-pressure turbine installation is disadvantageous both because of lack of space and because of the comparatively low initial pressure for the engine. The high-pressure turbine, therefore, is better adapted to the conditions, because it is more economical, more compact, capable of using high superheat and the operating and maintenance charges are less than with the engine-low-pressure turbine unit.

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[*] "Transactions," American Society Mechanical Engineers, 1910. Vol. 32, pp. 69-135.

The state of the art of engineering, the physical condition of the engines, available space—all favored the low-pressure turbine for the 59th Street Station, while they prohibit it for the 74th Street Station.

* *

Testing Engines in Office Buildings

By W. L. Durand

In many modern city-building power plants the engines are rarely tested after they are installed. In some instances the lack of facilities makes it impossible to test the engines for steam consumption without considerable preparation. In other cases where it might be possible to test one engine with the rest of the plant idle, it is not feasible, as when the engines are ready the demands require that one or more be kept running.

Reliability of service is of such importance that it is necessary to duplicate the plant in the most essential features. Where this is done it is easy to so arrange the piping that the engines and boilers may be run as two independent plants; with one pump, one boiler and one engine arranged for testing and the other pump and the rest of the boilers and engines for carrying the building load. The units forming these combinations can be varied as desired so that all of the engines can be tested. One method of arranging the steam- and boiler-feed piping is shown in Figs. 1 and 2.

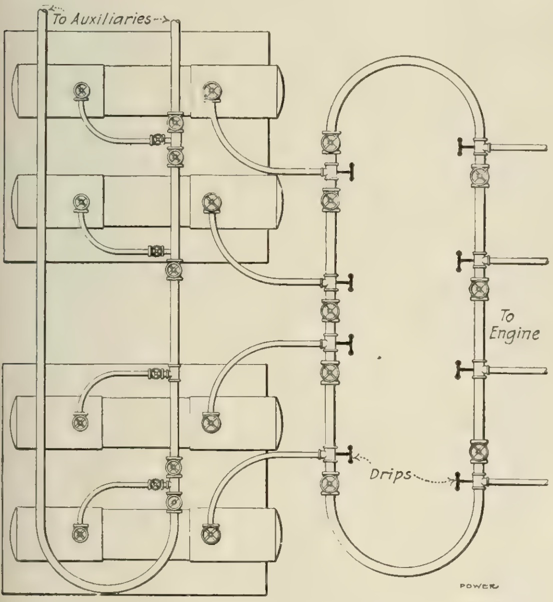


Fig. 1. Boiler-Room Piping

The easiest and most accurate means of weighing the water is by the two-barrel method. From the lower barrel a line is run to the suction side of the feed pumps, both of which should have a globe valve with which to connect. The water level in the boiler should be at the same level at the beginning and the end of the test, and the amount of condensation in the steam piping should be determined and subtracted from the total amount of steam to obtain the correct amount delivered to the engine.

This may be done without interfering with the operation of the drips from the rest of the plant by arranging drip piping as a part of the permanent equipment so that it is possible to test an engine at any time.

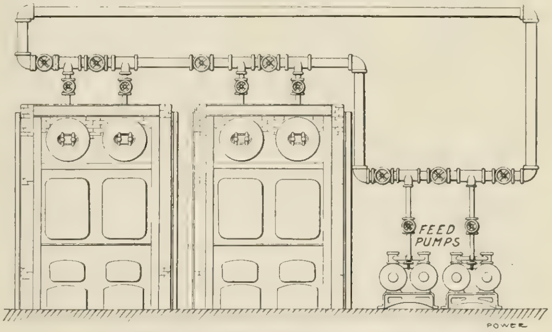


Fig. 2. Feed-Water Piping

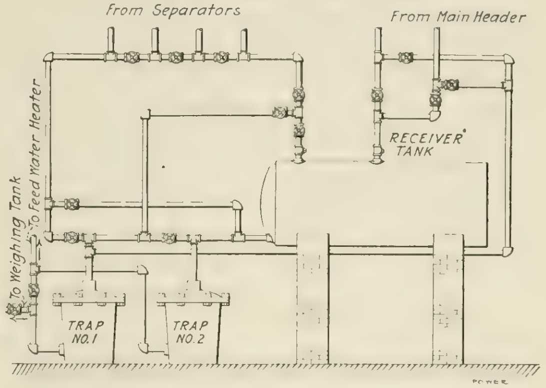


Fig. 3. Drip Piping for Line Condensation

As in Figs. 1 and 3, each half of the header is dripped and a separate line is run to the receiving tank; a separate line is also run from each engine separator. Trap No. 1 has a valve from which connection to a tank on a scale may be made. In making the test the drips from the half of the header and from the separator on the engine under test are run to trap No. 1 and weighed; the drips from the other engines and half of the header go to trap No. 2 and are discharged into the feed-water heater. In Fig. 3 it may be seen what combinations of valves are closed in order to operate the system.

To Find the Number of Integer Places in a Product or Quotient

By F. R. Low

When using a slide rule or calculating machine one cannot always point off in the usual way, because the right hand end of the answer is often lacking, and it is desirable to be able to point off from the left-hand end, i.e. to set off the integer instead of the decimal places. In applying the following rules count as having a minus number of integer places those which have, so to speak, less than none; thus

78.54	has	2 integer places	0.07854	has	— 1 integer place
7.854	has	1 integer place	0.007854	has	— 2 integer places
0.7854	has	0 integer places	0.0007854	has	— 3 integer places

Notice that the minus figure is indicated by the number of 0's between the first figure and the decimal point; as 0.007854 = — 2 because there are two 0's between the 7 and the point. The "first figure" of a number, as used in the following rules, means the first left-hand figure other than 0; as the 7 in all of the above instances. When "first figures" require to be compared and are identical, compare the first two, as in the second example under the first rule. If the first two are alike take in the 3d, etc.

In order to avoid repetition let me indicate by "sum" the total number of integer places in both factors; and by "difference" the result obtained by subtracting the number of integer places in the divisor from that of those in the dividend. This last quantity may be minus. In adding and subtracting the plus and minus quantities remember that in addition you take the sum of the two quantities only when they have the same sign, giving that sign to the sum; but if they have different signs you take the difference for the sum, giving to it the sign of the greater quantity. Thus the sum of + 2 and — 5 = — 3. In subtraction you change the sign of the subtrahend, or quantity to be subtracted and proceed as in addition. A number which has no sign is plus.

We will also indicate by *n* the number of integer places in the product or quotient.

MULTIPLICATION

When the first figure of the product is LESS than that of the factor having the greater first figure, **n = Sum**

999 = 3 plc 11 = 2 plc 10989 5 = sum 1 < 9 ∴ *n* = sum = 5*	999 = 3 plc 99 = 2 plc 98901 5 = sum 98 < 99 ∴ *n* = sum = 5	3.1416 = 1 plc 42.9 = 2 plc 134.77+ 3 = sum 1 < 4 ∴ *n* = sum = 3	4.3946 = + 1 plc 0.0031 = — 2 plc 0.0136 + — 1 = sum 1 < 4 ∴ *n* = sum = —1

When the first figure of the product is GREATER than that of the factor having the greater first figure, **n = Sum — 1**

273 = 3 plc 32 = 2 plc 8736 5 = sum 8 > 3 ∴ *n* = 5 — 1 = 4	1001 = 4 plc 999 = 3 plc 999999 7 = sum 9999 > 9990 ∴ *n* = 7 — 1 = 6	3.1416 = 1 plc 29.8 = 2 plc 93.61968 3 = sum 9 > 3 ∴ *n* = 3 — 1 = 2	0.7854 = 0 plc 0.0125 = — 1 plc 0.009817+ — 1 sum 9 > 7 ∴ *n* = —1 —1 = —2

DIVISION

When the first figure of the dividend is LESS than that of the divisor, **n = Difference**

4 plc 3 plc $\frac{1728}{231} = 7.48+$ 1 dif. 1 < 2 ∴ *n* = dif = 1	1 plc 1 plc $\frac{3.1416}{4} = 0.7854$ 0 dif 3 < 4 ∴ *n* = dif. = 0	— 1 plc + 2 plc $\frac{0.0149}{15.5} = 0.00096129$ — 3 dif. 14 < 15 ∴ *n* = dif. = —3

When the first figure of the dividend is GREATER than that of the divisor, **n = Difference + 1**

3 plc 2 plc $\frac{969}{17} = 57$ 1 = dif. 9 > 1 ∴ *n* = 1 + 1 = 2	+ 2 plc — 1 plc $\frac{62.34}{0.018} = 3463.33+$ + 3 dif. 6 > 1 ∴ *n* = 3 + 1 = 4	— 2 plc. + 2 plc $\frac{0.00823}{76.42} = 0.00010769+$ — 4 dif. 8 > 7 ∴ *n* = —4 +1 = —3

A consideration of why the product should have a greater number of places when its first figure is lower may serve to fix the rules in mind.

4 × 2 = 8

Here the "first figure" of the product is *greater* than that of the factor having the larger first figure, because the multiplication of 4 by 2 leaves it still under 10 and keeps it still a 1-place number but larger than it was to start with.

So with the greater first figure the product has the lesser number of places.

4 × 3 = 12

Here the first figure of the product is less than that of the factor having the larger first figure, because multiplying by 3 carries it over 10, but the greatest value that the first figure of this product can have is 4 × 999.... which will be less than 4.

So with the lesser first figure the product has the greater number of places.

---

*1 is less than (<) 9, hence (∴) the number (*n*) of integer places in the product equals the sum of those in the 2 factors, in this case 5.

When both of the factors commence with 3 the product will commence with either 1 or 9. When it commences with 1, n = sum, when with 9, n = sum — 1.

With this exception the product will carry over whenever both factors commence with a number greater than 2; so that *whenever neither of the factors commence with* 1 *or* 2, **n = sum,** except when both commence with 3. If we have 67.49 × 78.327 for example we know offhand (since neither of them commences with a 1 or a 2 nor both with 3) that their product will be a 9-place number of which 5 will be decimals leaving 4 integers.

Both of these cases come under the general rules given at first.

In the case of division the reason for the rules is equally obvious, and being understood will enable one to reconstruct them by a trial with simple figures.

24)8928(3
72

If, as here, the first figure of the divisor is less than that of the dividend the number (72) first subtracted from the dividend will have the same number of places as the divisor. The number of figures in the dividend still to be brought down is equal to the "difference" between those in the dividend and those in the divisor. Each of these means a place in the quotient and to their number must be added 1 for the figure already there.

So when the first figure of the dividend is greater than that of the divisor

n = difference + 1

36)1728(4 36)1028(2
144 72

If, as here, the first figure of the divisor is greater than that of the dividend the number first subtracted from the dividend (144 or 72) will extend under one more place in the dividend than there are places in the divisor. This leaves one place less than the "difference" still to be brought down and produce places in the quotient, and this 1 less place plus 1 for the figure already there makes the number of places in the quotient equal to the difference.

So when the first figure of the dividend is less than that of the divisor

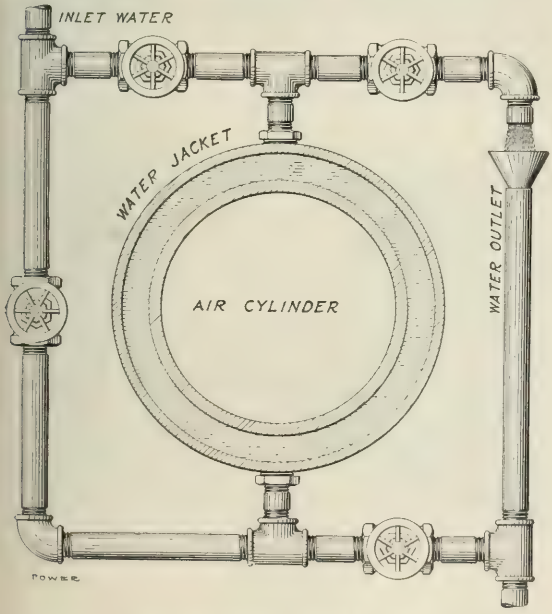
n = difference

* *

Air-Compressor Troubles

By A. G. Solomon

In the course of years of erecting, operating and repairing machinery of different kinds, the writer has found that usually the air compressor is neglected and abused more than any other machine in the plant.



Cooling-Water Connections

A case of poor location for two air compressors and several pumps once came to my notice in a Southern ice plant which had a light engine room containing the ammonia compressors and some smaller machinery. The air compressors and pumps had been placed outside, with no walls around them and a poor roof.

There was not much trouble until the cold weather set in. The plant was run only in the daytime, and every evening it required a good hour's work to drain the machines. The drains from the steam cylinders and valve chambers of the air compressors and pumps were piped into a 2-in. header discharging to the sewer. One morning a steam cylinder on a pump was found cracked, and it was discovered that the drain from this cylinder had become filled with cylinder oil which was thick from the cold and acted as a plug to hold back the water.

Another freeze-up was caused in an unusual way. The drains were always opened from the water jackets to let the water run on the ground. A cracked jacket was caused by sand collecting in the narrow spaces and containing enough moisture to expand when freezing. After that, the sand and sediment were loosened regularly with a bent piece of flat iron so that the water could wash them out.

A cross-connection between the water inlet and outlet will permit reversal of flow of the cooling water for a few minutes every day, thus washing out much of the sediment which would otherwise settle and perhaps cause trouble. The sketch shows the arrangement.

In compressors of the two-stage type the intercooler between the low- and high-pressure air cylinders must be watched closely for leaks in the water tubes and the gaskets. When the pressure on the cooling water is high, water will find its way into the high-pressure air cylinder and, even in small amount, it will wash off the oil and cause wear of the cylinder, the piston rings and the valves. If the water pressure is low there will be a loss of capacity, as the air will escape into the water. There are several arrangements for intercoolers, but leakage can be looked for in any of them.

My experience with the valve setting for straight-line compressors has been varied, but I do not believe that the indicator diagrams as ordinarily taken from the steam cylinder will ever be perfect. As the power exerted on the steam piston is greatest when the least amount of work is being done, the steam valves should be set late instead of giving them lead as is the common practice.

The energy in the flywheel is sufficient to carry the machine a good ways over the center. The ever-increasing load in the air cylinder will give all the compression needed, so that the exhaust valves should be set without allowing for any compression in the steam cylinder; then the machine will be found to run smoothly with cool bearings.

I ran across an annoying occurrence in an air compressor having the suction valves in the piston. At times this machine would act as if a suction valve were broken. I opened the cylinder one Sunday and found that three of the five slots for receiving pins to hold the suction valve in place were worn to twice their original length. This caused the valve to cock sideways and stick. The pins were unusually hard and had not worn at all. Nothing could be done at the time but order a new valve sent by express.

⁂ ⁂

Record in Building Large Engines

SYNOPSIS—Building a steam-driven air compressor with cylinders 48 and 84 by 60 in. in 38 days is a record. A second unit of the same size was built in 59 days. One unit required 16 cars for transportation. The engines weighed 1,800,000 lb., or 900 tons, and contained 10,210 pieces, the lightest weighing 1/4 oz., the heaviest 94,550 lb.

⁂

What is believed to be the world's record in building large engines was recently accomplished by the Mesta Machine Co., of Pittsburgh, Penn., in building two horizontal, cross-compound blowing engines for the Woodward Iron Co., Woodward, Ala. The first engine was completed and loaded on cars at the Mesta works in 38 days, and the second one in 59 days from the date of signing the contract at Woodward, Ala. Each engine consists of a high-pressure and low-pressure steam cylinder 48 and 84 in. in. diameter, and two air cylinders 84 in. in diameter; stroke, 60 in. The Mesta new type of horizontal, cross-compound blowing engine, Fig. 1, is equipped with their new automatic plate valves (Iversen patent) as shown in Fig. 2.

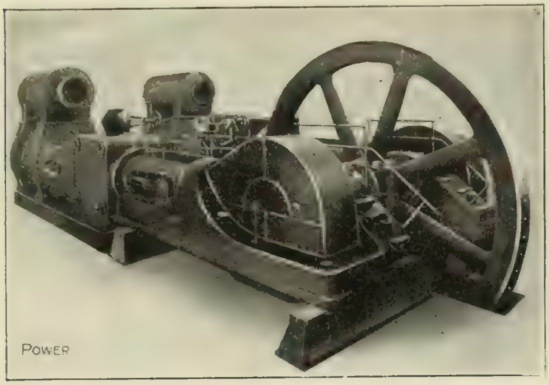
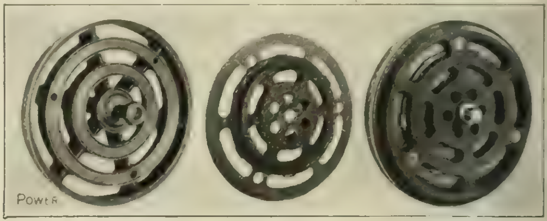


Fig. 1. Mesta 48, 84 and 84 by 60-In. Cross-Compound Blowing Engine

On Nov. 15, 1913, a contract was signed, the first engine to be loaded for shipment in 90 days and the second engine in 120 days; the contract contained a bonus and penalty clause, as the Woodward Iron Co. were doubtful that the Mesta Machine Co. could make delivery on the dates specified.

There were no engines in stock, as all engines of this size and type are built on special orders only. Work on these engines was started Monday morning, Nov. 17, the time when the order was received at the works.

On Dec. 22, the first engine was completely assembled on the erecting floor. On Dec. 23 at about 6 p.m., the engine was loaded on 16 cars ready for shipment, just 38 days from the time the contract was signed at Woodward, Ala. The engine was thus completed 53 days ahead of the time called for in the contract.



Valve Seat Valve Plate Assembled Valve

Fig. 2

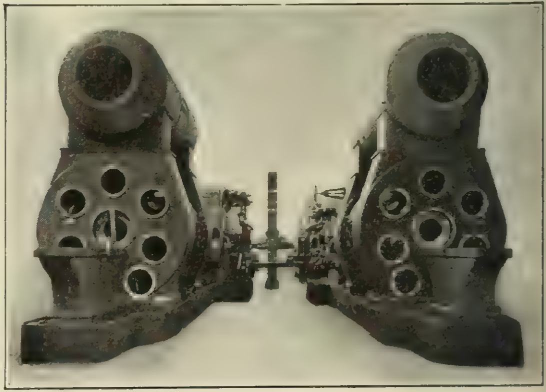


Fig. 3. How the Air Receivers Are Mounted above Air Cylinders

Arrangements were made with the Pennsylvania R.R. to run the 16 cars as a special train to Cincinnati and with the L. & N. R.R. to take it through as a special from Cincinnati to Woodward, Ala. The train arrived at Woodward on the morning of Dec. 27, three days from the time it left the Mesta plant. It is believed that this is not only the world's record in building engines of this size, but in delivering 900,000 lb. of machinery a distance of 834 miles in three days.

The second engine was completed on the erecting floor Jan. 12, 1914. It was loaded on the cars which left the plant Jan. 13, just 59 days from the date of signing the contract and was less than half the time called for in the contract, namely, 120 days. It was delivered at Woodward in just 57 hours after shipment.

The magnitude of the task is better realized by a statement showing the work handled. The engines weighed 1,800,000 lb., and contain 10,210 pieces. The lightest piece weighs ¼ oz., the heaviest piece 94,550 lb.

Description of the Engines

The engines are built with the air cylinders placed back of the steam cylinders, Fig. 2. Both the high- and low-pressure steam cylinders are equipped with Corliss valve-gears and the air end with Mesta automatic inlet and outlet valves; they require no valve-gear. A large receiver is placed over each air cylinder, which practically eliminates vibration in the air lines to the furnace. Fig. 3, a rear-end view of one of the engines on the erecting floor, shows the massive but simple construction of the air end of the blowing engines. The engines are designed for 30 lb. of air pressure and to run at a speed of 80 r.p.m.

Right to Water of Streams

By A. L. H. Street

The legal right of an owner of land bordering a stream to use water from it in generating power for mechanical or manufacturing purposes, by developing water power on the stream, has been defined by the appellate courts of the country. These decisions establish the following principal limitations upon the right: The use must be reasonable, and whether there is a reasonable use in a particular instance depends upon the volume of the stream and the needs of other land owners whose property adjoins. The right of owners to use the waters for domestic purposes is superior to that of other owners to use them to develop power. Water not necessarily consumed in mechanical use must be returned to the stream for the benefit of lower owners.

What is here said will be understood as applying to cases where the principles stated are not controlled by a special grant of water privileges, by the acquisition of rights by the long-continued adverse user, or by the law applicable to appropriation of water flowing through public lands.

Under the principle that the right to use a stream in generating power must depend, partly, upon the needs of other riparian owners, it has been held that the right to make such use in operating a mill is not to be measured merely by the amount of grain which the owner may have to grind. (Clark vs. Rockland Water Power Co., 52 *Maine Supreme Judicial Court Reports* 68.) The right of a company to utilize the Niagara River for manufacturing purposes was declared by the New York courts in the case of People vs. Smith (75 *New York Supplement* 1100.) Their decision grants the right to divert waters for that purpose, on condition that unconsumed water be returned to the river, but the New York Court of Appeals has denied the right of a riparian owner to sell a water supply to the prejudice of lower owners. (73 *Northeastern Reporter* 566.)

An Interesting California Decision

In sustaining the right of a company which owned land along a stream to use water therefrom to operate an electric power plant, the California Supreme Court said, in the case of the Mentone Irrigation Co. vs. the Redlands Electric Light & Power Co., (100 *Pacific Reporter* 1082): "The plaintiff makes the novel proposition that the use of the water to generate electric power by a power house on riparian land is not a use within the scope of the riparian rights which attach to the land, unless the electric power is not only generated upon that land but is, also, applied and used within its confines. There is no merit in this proposition. The riparian owner, by reason of the situation of his land, has the right to make any use beneficial to himself on the riparian land which his situation enables him to make, except that, if his use involves a consumption of the water, he may not use more than his reasonable share as compared with other owners, and that he must not pollute the water to the injury of others entitled to it, and that the water he does not consume must be returned before it passes his land. . . . The theory of the plaintiff on this point would seem to come to this: That in the process the water is in some way transformed into electricity, and in that form is carried away and used on nonriparian land. . . . But no such thing occurs. The water is not changed into electricity, nor carried away by the process. . . . It is the force of gravity which turns the wheels, and, being converted into electric power, is carried away on the wires, the water itself being turned back into the stream, as is the case of its use to turn an ordinary mill wheel."

The right to divert the water through an artificial channel on the company's lands was recognized in this case, the same as in the New York case mentioned, subject to the duty to avoid unduly impairing its use by other owners interested.

Right Subordinate to Domestic Use

"The right to the use of water for domestic purposes is primary, and the right to its use as a mechanical power is secondary; and to the extent that the two rights conflict, its use as a mechanical power must be surrendered. Water for use as power should receive reasonable protection. Water for domestic use, and by which the health and cleanliness of the people, and protection against fires are to be secured, is, also, important." (Maine Supreme Judicial Court, City of Auburn vs. Union Water Power Co., 38 *Atlantic Reporter* 561.) If a stream has so small a volume that it does not furnish more water than is required for domestic use by the owners of land bordering the stream, none of them can consume this water to create mechanical power. If the water is not used for domestic purposes, no owner can use it all for manufacturing purposes, to the exclusion of others who may desire to make a similar use. In such a case the water is to be equitably divided, according to the requirements of the several parties.

Largest Keeler Boiler Ever Built

The Nichols Copper Co., Long Island City, N. Y., has the distinction of operating the largest Keeler water-tube boiler ever built. The boiler is set above the new reverberatory furnace, as in Fig. 1. The temperataure of the furnace gases going to the boiler is approximately 1500 deg. The firebox of the boiler is connected to the reverberatory furnaces by a duct entering at the bottom of the boiler furnace and is the width of the boiler. The inside wall of the hot-gas duct extends above the furnace bottom to form a bridge-wall, Fig. 2.

In Fig. 1, is shown the method of connecting the 10-ft. smoke flue at the rear end of the boiler. The breaching rests on the brick work and forms a saddle for the flue, which drops at the rear end of the boiler setting and connects with the chimney. Fig. 3 gives an idea of the construction of the riveted smoke flue, and of the damper arrangement, the damper being operated by hand, by a chain from the deck below by the attendant.

The boiler is of 1280 hp. capacity, contains 12,780 sq.ft. of heating surface, and is designed to carry 220 lb. pressure. There are three steam drums, each 48 in. in diameter, and 23 ft. 9 in. long. The 578 four-inch seamless tubes are 20 ft. long, and are made of No. 9 gage steel. The drum shells are $\frac{9}{16}$ in. thick, with triple-riveted, butt-strap joints, and are fitted with heads $\frac{5}{8}$ in. thick. A 5-in. safety valve is attached to each drum, which has an 8-in. steam outlet. The boiler complete weighs 200,600 lb.

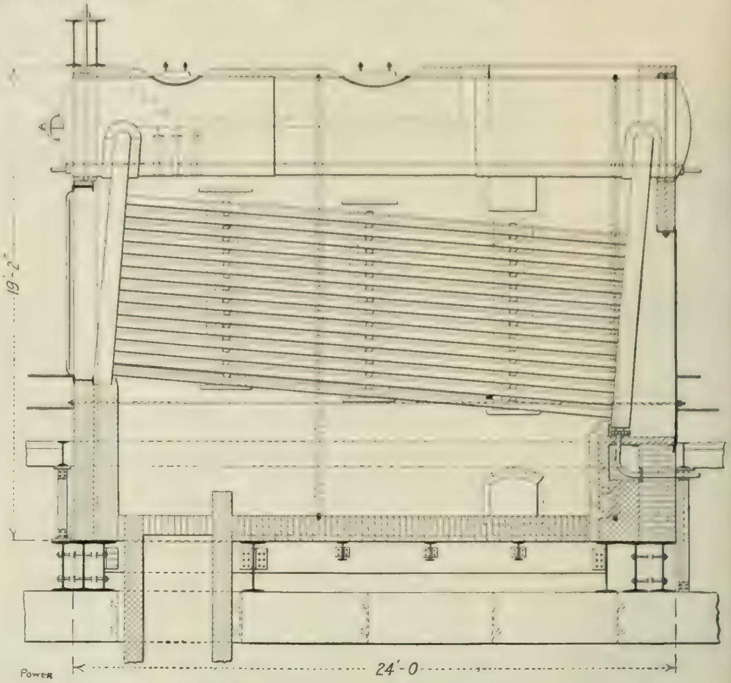


Fig. 2. Design of Boiler Furnace

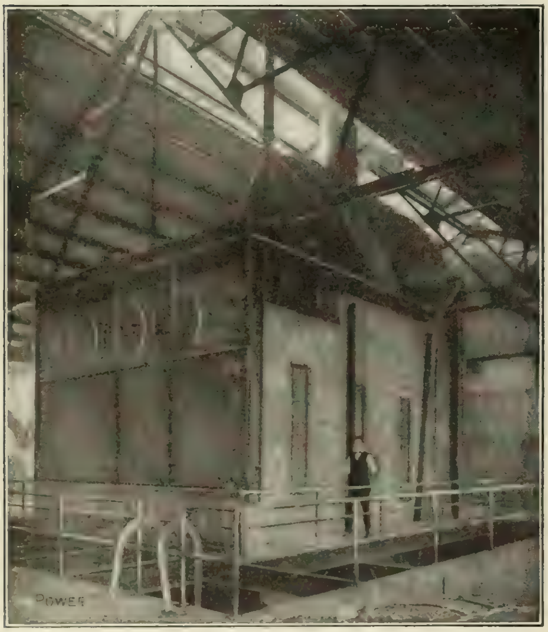


Fig. 1. Boiler Setting over Reverberatory Furnace

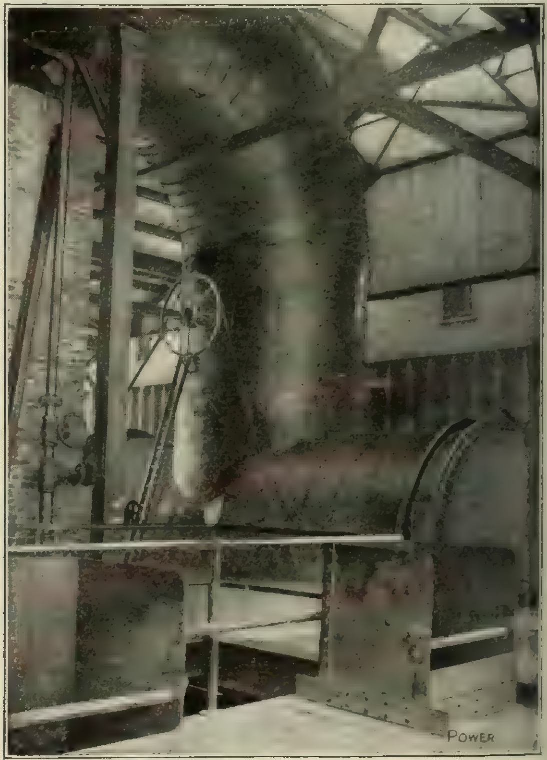


Fig. 3. Construction of the 10-Ft. Smoke Flue

Turbine-Driven Rotary Compressors

By Dr. Alfred Gradenwitz

A short time ago, a remarkable turbo-compressor was completed at the Allgemeine Elektricitäts Gesellschaft turbine factory, which is capable of delivering the enormous quantity of 3,531,400 cu.ft. of free air per hour at a pressure of 140-170 lb. per sq.in. This output corresponds to a power input of 12,000-13,000 b.hp.

This is one of three compressors of the same output to be supplied to the Victoria Falls & Transvaal Power Co. This company was the first to avail itself of the advantages afforded by large-size turbo-compressors and to adopt the transmission of power in the form of compressed air on a large scale. The company already has twelve 4000-hp. turbo-compressors in commission in its power stations, situated close to Johannesburg. The compressed air generated by these machines is transmitted through a pipe line 18.6 miles in length and supplies 17 mines, for operating rock drills and other compressed-air tools. The installation of the three new compressors will raise the total amount of energy transmitted in the form of compressed air to 84,000 hp.

Fig. 1 shows the general arrangement of the compressor referred to in the foregoing. On the left-hand side is the steam turbine, designed for high-pressure, superheated steam, and fitted with automatic nozzle regulation. This is the first turbine built to give an output of 12,000 hp. at a speed of 3000 r.p.m.

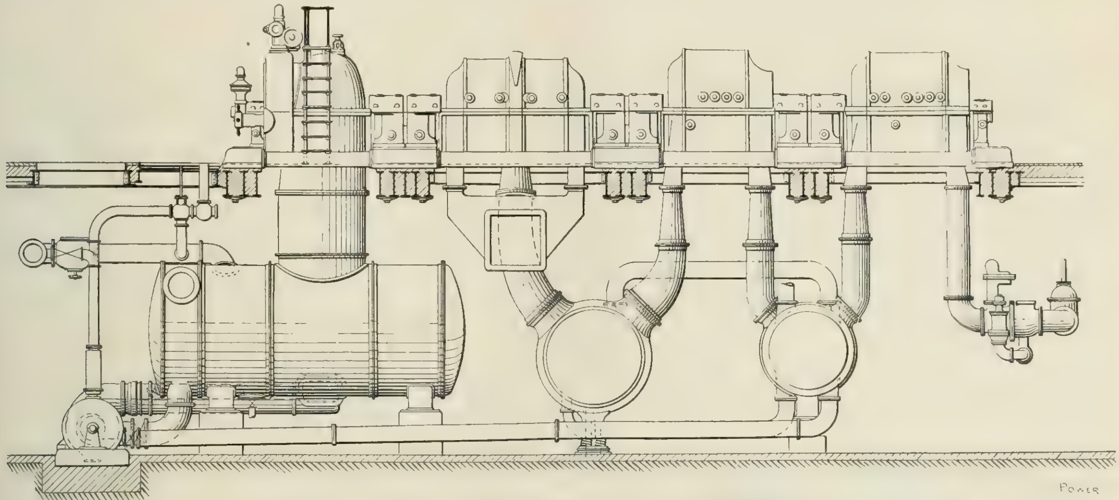


Fig. 1. General Arrangement of the Compressor

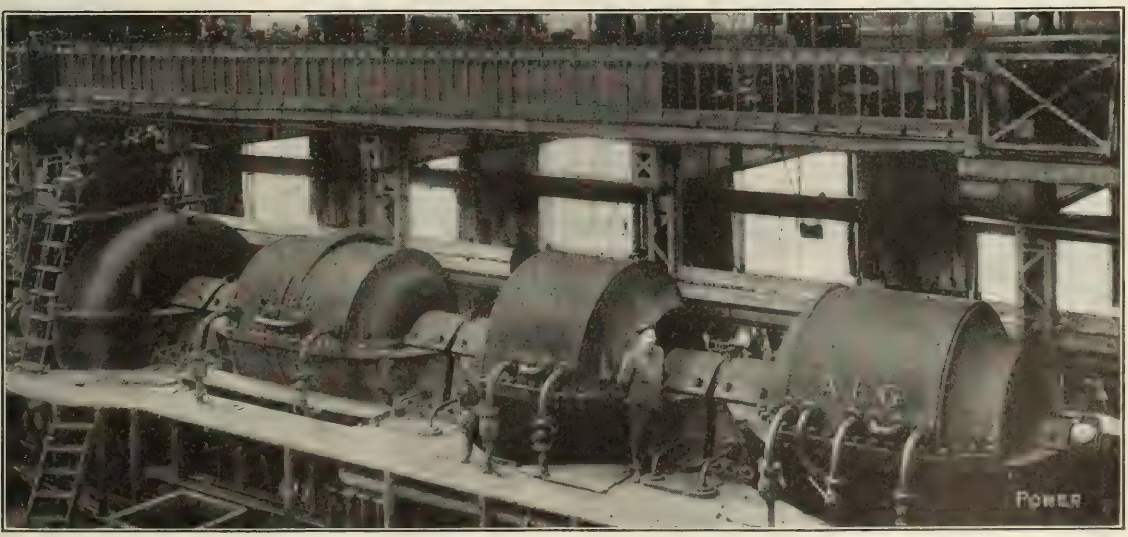


Fig. 2. Compressor on the Testing Bed

The compressor, consisting of three cylinders, is connected to the steam turbine by a flexible coupling. The low-pressure air cylinder is next to the turbine, and in view of the large quantity of air handled, is designed to draw in air on both sides. The air passes from the main suction pipe, the square section of which is visible in Figs. 1 and 2, into the two ends of the low-pressure compressor, passing out to the intermediate cooler, slightly compressed at a temperature of about 100 deg. C., in which it is cooled to about 30 deg. C.

The intermediate cylinder, through which the air next passes, is constructed with an intake on one side only, as the volume of air has been so reduced that it is no longer necessary to divide the air current on account of the section of the impellers. The air compression is further increased in this cylinder, and the air passes out of it in a highly heated condition, to be cooled again in a second cooler, Fig. 1, whereupon it enters the high-pressure cylinder for final compression and is then discharged to the pipe line through the pressure pipe shown in Fig. 1, on the right.

As the cooling effect in the intermediate coolers is not sufficient to permit the process of compression to be carried out economically, the compressor cylinders themselves are water cooled. The pipe lines through which this water is brought is shown in Fig. 2, which is a view of the compressor on the test bed.

The light foundations upon which the turbo-compressor is erected are especially noteworthy. They permit the intermediate coolers with their piping and the condenser plant for the turbine to be installed conveniently below them in the basement.

This first 12,000-hp. compressor, on test, satisfied the guarantee conditions for steam consumption, which were more severe than would have been thought possible for units of 1000 to 2000 hp. The units ran on the test bed for several hours with a load up to 12,000 hp., corresponding to normal working conditions.

⁂

Nonpareil Insulating Brick

This type of brick is used to back up firebrick where the retention of heat is desirable, and not as a substitute for firebrick. It is composed of diatomaceous earth, minute skeleton shell plants, of almost pure silica, finely ground cork and clay. When the brick is fired the cork is first carbonized and then gradually burned out, which leaves the brick porous. Each brick is 9 and 4 by 2½ in. in size. It is suitable for use in boiler settings, gas producers, or in the construction of any type of heating furnace, ovens or kilns, etc. A brick weighs but 1½ lb. but will readily withstand a crushing strain of 140 lb. per sq.in.

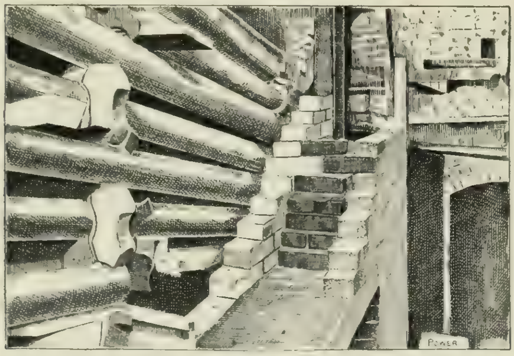


Fig. 1. Nonpareil Brick as Used in a Boiler Furnace

The bricks are laid in a special insulating cement, requiring 400 lb. per 1000 bricks. They may be laid in several ways, outside of the firebrick and the common brick of a boiler setting, Fig. 1. When placed outside the common brick, the exposed surface may be finished off with a coat of cement plaster, Fig. 2. In any case, an inner lining of firebrick must be used, for the insulating brick is not a refractory material and will not withstand the abrasion to which firebrick are subjected.

To hold the courses of different brick together, metal ties extending through the common brick to the firebrick can be utilized, as in Fig. 3, or the brick can be tied together in the ordinary manner. The two, however, make a serviceable setting.

These bricks, made by the Armstrong Cork Co., Pittsburgh, Penn., require six to the square foot for a 4-in. wall. They are shipped in crates holding 88 bricks or in any increased quantity.

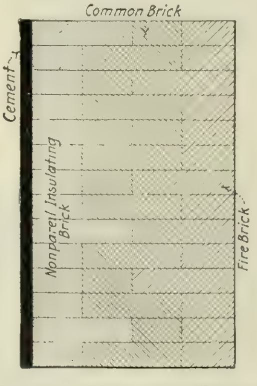


Fig. 2. Insulating Brick and Cement Coating

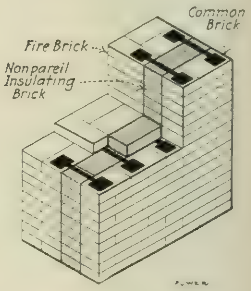


Fig. 3. Method Employed in Tying Courses of Brick

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Providence Hotel to Operate a Plant—The Narragansett Hotel, in Providence, R. I., has, after a long contest between the isolated and central-station advocates, decided to put in a plant of its own. Even when the isolated plant was handicapped with a fixed charge of 16 per cent. and a steam rate of 29 lb. per indicated horsepower-hour, the resulting average cost per year was under two cents per kilowatt-hour at the switchboard. They are now paying about three times that rate to the electric company, the load being mostly lighting. Two Ideal Corliss-valve engines will be used, guaranteed to produce an indicated-horsepower-hour under 25 lb. As the boilers were already installed, and as the hotel has considerable use for exhaust steam, the additional cost for light and power should be very low.

Testing Arc-Light Circuits

By James Brakes, Jr.

SYNOPSIS—Directions for testing for breaks and grounds on arc-light circuits by means of a magneto and bell.

⁂

Since street arc-lighting circuits are generally long, considerably exposed and of comparatively small wire, they always give more or less trouble on account of grounds, breaks and crosses.

Grounds are most likely to occur around the fronts of stores where wires are run in proximity to iron awning frames or fittings. Also, where the lines run through trees, there will always be more or less of a ground, especially in wet weather. In this case, however, the trouble would be more correctly termed a leak, as it is due to defective insulation and does not constitute a direct connection to the ground, as would happen, for example, if one of the lines came in contact with an iron pole or a gas or water pipe.

All arc lines should be tested at intervals during the day to see if any faults have developed, so that they can be looked up and remedied, if possible, before it is time to start up in the evening. This may be done in various ways, but in many cases grounds and breaks are located by the use of an ordinary magneto bell. This is able to ring through a long length of line, and is easily carried around from place to place.

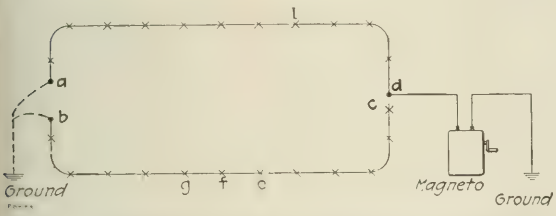


Fig. 1. Locating Break by Means of a Magneto

Locating Breaks

Series arc circuits should be tested frequently for breaks by connecting a magneto to the terminals of the circuit at the station, and ringing through it. If the bell fails to ring, it shows that the circuit is broken somewhere and the break should be looked up at once. If the circuit is arranged in loops that can be cut out by means of switches on the poles, the first thing to be done is to cut out the loops in succession until a ring is obtained. This will show in which loop the break is, and the fault can then be further located, but in many cases it may be found by a simple inspection. In general, however, the problem will be to locate a break on a simple series circuit, such as that represented in Fig. 1.

Assume that it is found by ringing up between *ab* and the station terminals, that there is a break in the circuit. First connect *a* and *b* together and ground them, as shown by the dotted lines. Then go to point *c* as near the middle of the circuit as possible, and open the circuit by lowering a lamp and removing the wires, or in any other way that may be convenient. Ground one terminal of the testing magneto, by connecting it with a hydrant or other ground connection, and attach the other terminal to one end of the circuit *d*. Ring through, and if the bell rings, it shows that the part of the circuit from *d* around to the station is all right and that the break is in the other half.

Now close the circuit at *c* and move on to *f*, about halfway between *c* and the station. The circuit is now opened and the magneto connected as before. If a ring is obtained when the bell is connected to the left-hand end of the line, it shows that the stretch of circuit *fgb* is intact; while, if the bell does not ring when connected to the right-hand side, it shows that the break is between *f* and *c*, as at *e*, because the previous test showed that the part *dla* was all right. In this way, by making a few tests, the stretch of a circuit in which the break occurs can be located within narrow limits, and the break itself can then usually be found by a careful inspection.

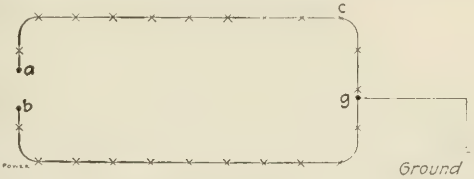


Fig. 2. Illustrating Ground in Arc-Lighting Circuit

When a line becomes grounded at any point *g*, as indicated in Fig. 2, the ground may be located by using a magneto, in which case the ends of the line *ab* at the station are left open, instead of being grounded as when testing for breaks. The line is then opened at *c* near the middle point and each side is rung up, one terminal of the magneto being connected to the ground. The side on which a ring is obtained is the one on which the ground exists. The half on which the ground is located is then opened at its middle point, and in this way the part of the line that is grounded is soon located within narrow limits.

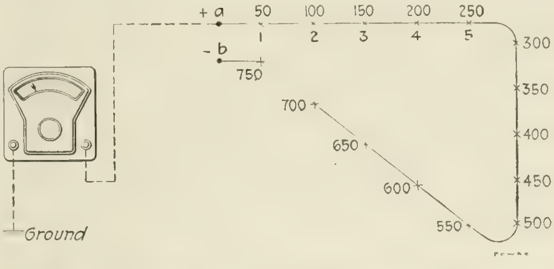


Fig. 3. Locating Ground by Means of Voltmeter

Locating Grounds by Means of a Voltmeter

If a high-reading voltmeter is available, it can be used for locating grounds on an arc circuit as indicated in Fig. 3.

In this case, there are, say, 15 lamps operated on the circuit. Let the total pressure generated by the dynamo be 15 × 50 = 750 volts, allowing 50 volts per lamp (including its proportion of the line drop). The difference of potential between the negative side of lamp No. 1, and *a* is 50 volts. Between the negative side of No. 2 and *a*, 100 volts, and so on, as indicated. If one terminal of the voltmeter is connected to *a* and the other to ground, a reading will indicate a ground on the line.

Suppose, for example, that there is a ground on the line at *g'*; the voltmeter will then be connected across four lamps, and will give a reading of about 200 volts. The voltmeter reading, therefore, indicates how far the ground is out on the line. If a reading of about 100 volts is obtained, it is known that the ground is somewhere between the second and third lamps.

* *

Calculating Pressures and Temperatures in Diesel Engines

By C. R. Courtenay

SYNOPSIS—By means of the chart, the temperature corresponding to any given compression pressure may be found; also the necessary clearance volume to produce this pressure and temperature.

*

Some time ago, the writer was called upon to assist in the design of a 75-hp. Diesel engine, together with a two-stage air compressor, which was to furnish air at 1000 lb. for fuel injection. Accordingly, a set of compression and temperature curves were laid down, that would serve as a handy reference in present and future calculations. Since the curves were got out, many occasions have arisen for their use in connection with gas-engine, oil-engine and compressor work, and they have saved much repetition of calculations. They cover a range of compression from atmospheric pressure to 1000 lb. absolute, and for varying conditions from adiabatic to isothermal.

The bottom scale represents volumes, while at the left the absolute pressures are shown both in pounds per square inch and in atmospheres. At the top are divisions representing temperatures (Fahrenheit). It will be unnecessary to use these divisions, however, as the temperatures are all carried out at the right of the curves and can be read directly.

Corresponding to each compression curve, are two temperature curves—one for 32 deg. initial temperature, and the other for 60 deg. initial temperature.

It will also be noticed that there are four compression (volume) curves giving a range, as stated, from adiabatic to isothermal. In laying down these curves, it was thought best to cover the two extreme conditions and then lay down between them the two curves 1.3 and 1.35, which would cover the conditions to be expected in actual practice. The numbers 1.30 and 1.35 represent the exponents of the *PV* curve under these intermediate conditions and 1.41 that with adiabatic compression. Curve 1.35 would represent the conditions with fair cooling of the cylinder, while curve 1.3 would represent conditions under still better cooling.

An example will best show how to use the chart. Suppose it is desired to know the volume and temperature at the end of the compression stroke in a Diesel engine, assuming that air is taken in at 32 deg. F., and that the compression pressure is 550 lb. absolute. Assume that the cooling is fair, hence choose the curve marked 1.35.

Following up the left-hand column, we come to 550 lb. Now pass to the right, as shown by the broken lines, until the 1.35-32 deg. heat curve is reached. Follow vertically from this point to the top scale, where we will find a corresponding temperature of 797 deg. or we can pass horizontally to the 1.35 column and find 797 deg.

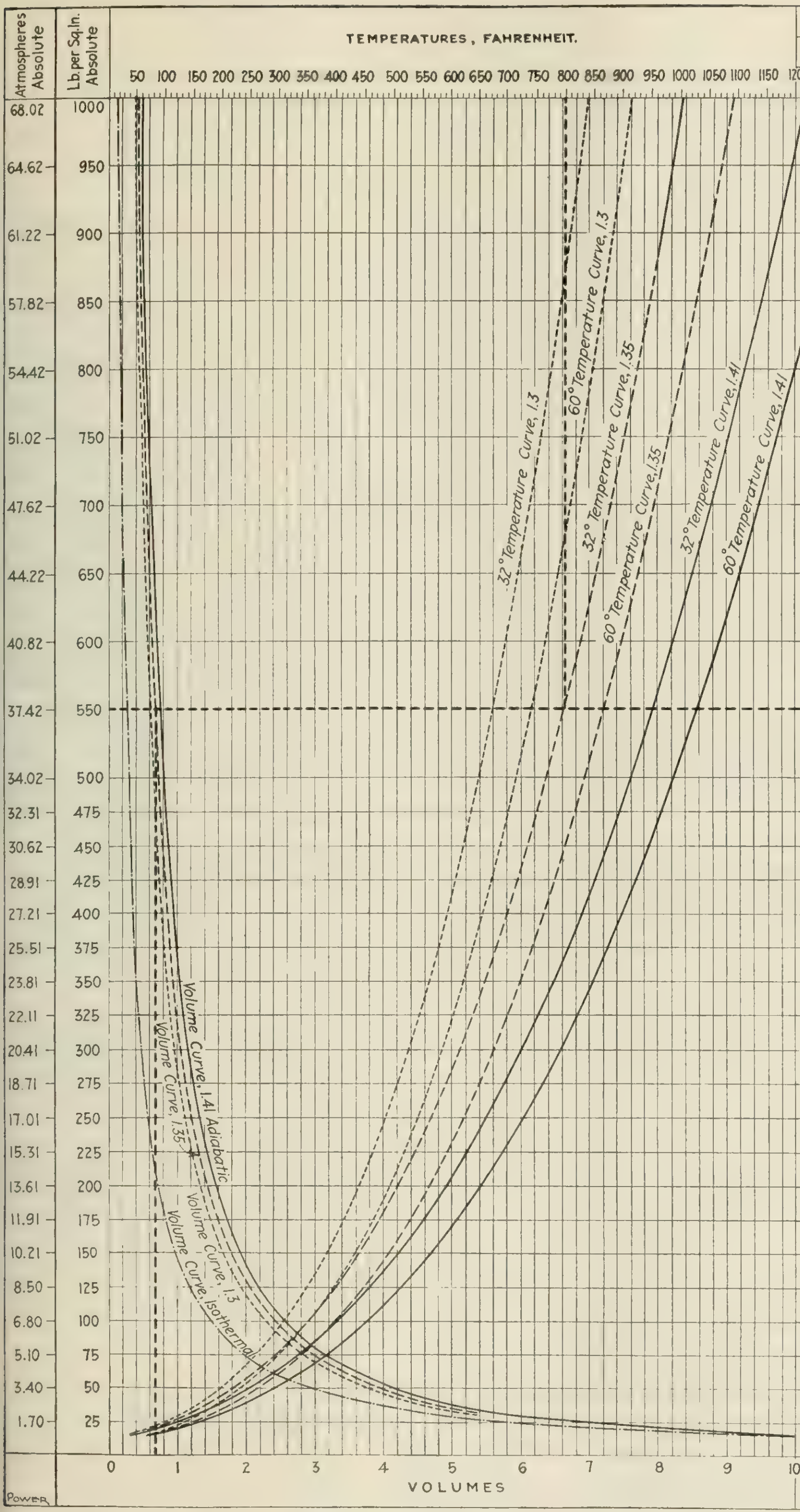
To find the corresponding volume, start at 550 lb. again and pass along the horizontal line to the right to the 1.35 compression curve. Directly below and on the base line is found 0.069, which means that the quantity of air taken into the cylinder has been compressed into a space 0.069, or 6.9 per cent. of its original volume. From this volume, one is enabled to calculate the necessary clearance space in the engine cylinder.

It might be mentioned that in practice this clearance volume is usually made somewhat less than the table shows, as the volumetric efficiency never reaches 100 per cent.

In the foregoing example, if the initial air temperature had been 60 deg. F., instead of 32 deg. F., it would have been necessary to pass along the horizontal line from 550 lb. to the column headed 1.35 and 60 deg. initial temperature and the result would have been 868 deg. or a rise of 71 deg. for a difference of 30 deg. in the intake temperature.

The question has already been raised by Mr. Wentworth, in Power, of raising the initial temperature of the air in the Diesel engine and thereby lowering the compression pressure. In the first example mentioned, the compression was 550 lb. absolute, the intake 32 deg. and the final temperature 797 deg. Suppose that this temperature is sufficient for complete combustion in a Diesel engine cylinder. Assume that air is taken into the cylinder at 60 deg. instead of 32 deg. and see what compression is necessary to produce this temperature. First, look under the column marked 60 deg. initial temperature and 1.35, and we will find 800 deg., which is near enough to 797 deg. for practical purposes. Now, follow the horizontal line from 800 deg. to the left and we find 450 lb. absolute, the compression pressure necessary to produce this temperature. This shows that the compression has dropped from 550 to 450 lb., with practically the same final temperature.

The above example shows that Mr. Wentworth's theory is not without foundation. It should be mentioned, however, that by raising the temperature of the intake air, the weight which can be taken into the cylinder is decreased. This is so because the volume of air so heated is increased, and this increase is in direct proportion to the absolute temperatures. In other words, the volumetric efficiency is decreased.



Temperatures Corresponding to Pressure, Deg. F. opposite.					
For 32° Initial Temp.			For 60° Initial Temp.		
1.3	1.35	1.41	1.3	1.35	1.41
840	1007	1220	917	1094	1315
825	988	1195	901	1073	1288
808	968	1169	884	1051	1260
792	947	1142	866	1028	1231
775	925	1114	847	1004	1201
756	902	1085	828	979	1170
737	878	1054	808	953	1138
717	853	1022	787	926	1105
695	826	988	764	898	1070
672	797	952	740	868	1031
648	766	913	712	835	990
635	750	893	700	818	968
621	733	872	685	800	946
607	715	850	670	781	923
592	697	827	654	761	898
577	678	803	637	741	873
561	658	778	619	720	846
543	637	751	601	698	819
525	615	723	582	675	790
505	591	694	562	650	759
485	565	662	540	622	725
462	537	628	516	592	689
437	507	592	490	560	651
410	475	552	461	527	608
379	438	507	429	489	562
345	397	457	392	445	509
305	348	400	349	394	448
256	290	331	298	333	375
192	216	243	230	254	282
96	105	114	128	137	147

Pressure-Temperature-Volume Diagram for Different Degrees of Compression

Double-Cushion Quick-Closing Trip Valve

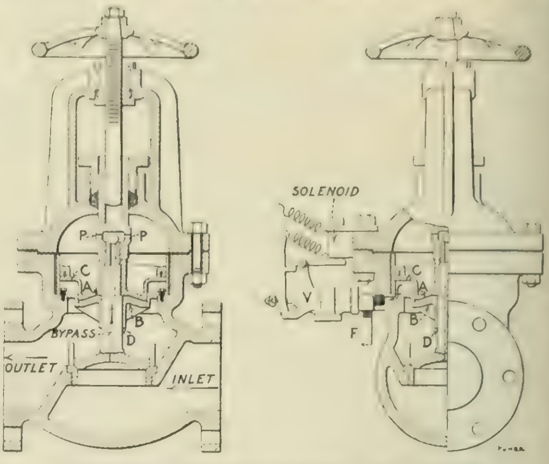
An electrically operated emergency trip valve is illustrated herewith. It is intended as an emergency shutoff or engine stop valve, that may also be operated by hand, or by an electrical solenoid and push button from any part of the plant. This valve is built by the Golden-Anderson Valve Specialty Co., 1217 Fulton Building, Pittsburgh, Penn.

The sectional view shows the Corliss double-dashpot method of cushioning the valve disk, the dashpot occupying the upper part of the valve body. This feature insures a cushion in the opening and closing of the valve disks, and brings them in alignment with the seats when closing, regardless of the position of the valve. The inside dashpot is shown at *A*, attached to the valve spindle D. The outside bronze dashpot *B* acts as a cylinder and is held in place by cap bolts.

A bypass is made through the valve stem from the under side of the valve disk, which is under boiler pressure, to the upper side of the dashpot *A*, through the ports *PP*. A port at *C* also admits steam at boiler pressure, which balances the dashpot *A*.

As may be seen in the semi-sectional view of the valve, an exhaust port communicates with the space between the two dashpots and leads to the pilot valve *V*.

When the pilot valve is tripped the steam pressure between the two dashpots escapes through the drip pipe *F* and allows the valve to close, thus shutting off the flow of steam through the valve. When this occurs the double-cushion feature gives an instantaneous drop to within $\frac{1}{8}$ in. of the seat, and then closes easily under the control of the secondary dashpot. By turning the handwheel, the stem may be screwed onto the top of the valve stem, thus making a steam tight joint and causing a permanent closure of the valve. The valve *V* is controlled by an electric solenoid connected to either direct or alternating current for continuous or intermittent service.



Sections of the Emergency Trip Valve

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Practical Refrigeration-Plant Suggestions

By William S. Luckenbach

SYNOPSIS—Impurities in the feed water may carry over with the steam in a distilled-water ice plant and seriously affect the ice. A bypass from the weak-liquor pipe to the ammonia pump may be used to relieve the gas in the pump. Condenser coils exposed to the sun's heat should be shaded; the covering also creates a draft between the coils. Thermometers in the liquor anhydrous pipe near the receiver, in the weak-liquor pipe near the absorber, and in the water line, if an ice plant, are as important as the brine thermometer. Suggestions on cleaning equipment.

*

The season is at hand when every owner and engineer dealing with ice-making and refrigerating plants should endeavor to improve on last season's output without expensive alterations.

A surface blowoff should be used when ice is made from distilled water. A heater and purifier to heat the water to not less than 210 deg. F. should be used, when ice making is the object, because at that temperature the larger portion of the impurities in the water will be precipitated before leaving the heater. The less impurities forced into the boiler the less there is to blow out, or form scale; the less the blowoff is used the less hot water goes to the sewer, less fuel is wasted and there is less work for the fireman. A high- and low-water alarm is an advantage, especially the high alarm, where distilled water is used for making ice, for if the water in the boiler should get too high the steam might carry some impurities with it, and should the filter not be capable of cleaning properly the foreign matter would pass into the cans and possibly 48 hr. later one would find bad ice without being able to account for it. A water-level alarm tends to make the fireman more particular about the water level.

Pumps

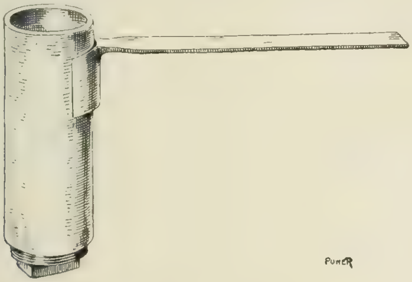
See that the clearance of all ammonia pumps is small to prevent the pump getting gas bound. To quickly remedy trouble of this kind have a permanent bypass of, say, 1-in. pipe from the weak-liquor pipe to the pump suction with a valve connected in the lines. If gas accumulates in the pump, open this valve and allow the weak liquor to enter the pump and absorb the accumulated gas, after which close the valve and run as usual.

Should the water supply be from a river or well, be sure the check valve on the end of the suction is working rightly, and that it will not fail during the busy season when tons of ice may be quickly lost. Do not stand on the bank of the river or top of the well and guess it will last another season, but hitch a chain block to it and get the valve out and examine it. One will have plenty to worry about during the season without courting a job like this.

In case of an absorption machine, the generator coils or tubes should be cleaned, as there is frequently some impurity in the aqua ammonia which adheres to the pipes and forms a nonconductor of heat, especially is this necessary where low-pressure or exhaust steam is used in the generator. Supply the generator with strong aqua ammonia, because the stronger it is the less heat is required to liberate gas, and as there will be less heat in the gas when reaching the condenser there will be less cooling water needed.

Condenser and Weak-Liquor Coils

The condensing coils for both the weak liquor and liquid anhydrous, whether of the ordinary atmospheric or double-pipe type, should be ample to allow both liquors to leave the coils at or near the temperature of the cooling water. To save cooling water have the coils in the open and get the benefit of a breeze from any quarter. It is common to see condensing coils on the roof without protection of any kind from the heat of the sun. A simple canvass covering would not only reduce the heat, but create a draft through the coils and help lower the temperature of the cooling water by evaporation.



Receptacle for Testing

The weak-liquor pipe leading from the cooling coils to the absorber, and the liquid anhydrous pipe leading to the receiver or expansion valve, should be run through the coolest part of the building to maintain a temperature approximately the same as that at the condenser outlet. If this cannot be done, it would pay to cover the pipes to protect them from the warm surrounding atmosphere.

Referring to the standard table of properties of saturated ammonia, we find that 1 cu.ft. of liquid ammonia at, say, 85 deg. (167.4 lb. pressure) weighs 37.10 lb., and 1 cu.ft. of gas weighs 0.5595 lb. Therefore, a cubic foot of liquid at 85 deg. F. expands $37.10 \div 0.5595 = 66.3$ times. Liquid anhydrous at 65 deg. F. (118.1 lb. pressure) weighs 38.09 lb., while a cubic foot of vaporized ammonia at this temperature weighs 0.3996 lb., and the volume of gas will be $38.09 \div 0.3996 = 95.2$ times that of the liquid. The ammonia at $85 - 65 = 20$ deg. lower temperature expands 28.9 additional times and extracts a proportionately greater amount of heat from the brine.

Thermometers

The more general use of thermometers in ice plants regardless of the kind of system, but especially in the absorption plant, should be advocated. There should be one on the feed pipe between the feed pump and steam boiler. When the heater becomes dirty and the absorption of heat is slower, the thermometer will indicate the condition. Thermometers in the weak-liquor pipe near the absorber and in the liquid anhydrous pipe near the receiver or expansion valve assist greatly in getting economical results from the plant. Suppose the normal temperature of the liquid ammonia at the expansion valve was 70 deg. F., and that of the brine 10 deg. F. The engineer in glancing at the thermometer notices a rise in temperature of 7 deg. F. He knows that the gas at the higher temperature will absorb less heat from the brine and result in an increase in the brine temperature. With the thermometer in front of him there is no good reason why the brine temperature should increase several degrees and why he should tramp around and wonder what caused it. He will know at once that there are only two causes, either too little cooling water for the condenser, or that the coils need cleaning, or that it is due to a combination of both. If an ice plant, the water to be frozen needs the same attention. Any rise in its temperature means that a correspondingly greater number of heat units must be extracted by the brine. The practice of feeling the water pipe to determine temperature variations is poor. Not one in 50 can detect a difference of 8 or 10 deg. in temperature. It would be just as sensible to discard the brine thermometer and rely on getting the correct temperature by dipping the hands in the brine. Another matter of importance is to insert near the expansion valve on the high-pressure side, a valve through which liquid anhydrous can be drawn off and tested for its purity. The test is made by using a cup made of 1-in. pipe plugged at one end and with a handle attached. A tube or nipple from the test valve should reach nearly to the bottom of the test cup. Draw a little liquor into the cup. If the ammonia evaporates clean and dry, it may be considered practically pure.

The Absorber

All absorbers operate to produce one result, i.e., to have the expanded gas from the brine tank absorbed by the weak liquid from the generator, to get the original strength of the ammonia. While the liquor will readily absorb the gas, it must be cold enough to absorb the quantity necessary for the liquor to regain its original strength. Therefore, the tubes or coils in the absorber must be clear and clean so that the exchange of heat between the cooling water and weak liquor will be rapid. When the absorber cannot be shut down for long the tubes may be cleaned with water or steam at high pressure. Steam cuts the scum from the coils better than water, but it also raises the temperature of the absorber, but by doing the cleaning when there is a large amount of ice on hand, half of the coils may be cleaned at one time without considerably decreasing the output.

BRINE TANK

If the brine tank has not been cleaned for a few seasons it should be cleaned as soon as possible to avoid rusting. Have the coils disconnected top and bottom and blow out each coil separately with steam, followed with air or apply heat to evaporate any water left in the pipe. In freezing weather, finish one coil complete before blowing the next, and give all coils a pressure test. They should stand 300 lb. pressure. In connecting the coils use only the best quality of rubber for flange joints, because many of these joints are difficult to get at when the plant is in operation. Have all nuts run loose on the bolts, and see that the nuts do not jam into the body of the bolt as leaks may follow.

PIPE AND FITTINGS

Use extra-heavy pipe and fittings on the ammonia system. In cutting pipe it frequently happens that the cutters depress the pipe, reduce the area and leave ragged edges on which foreign substances gather. Do not use a nipple or piece of pipe without looking through it for blisters and obstructions, as this precaution may save much trouble later on. In making screwed ammonia joints do not use pasty substance of any kind, as the particles get jammed between the threads and, while the joint may be tight, it will be only a short time when the ammonia will leak through at a time when one has plenty of other urgent matters on hand. The first requisite is a good, clean thread on both pipe and fitting, then dip them in a mixture of lubricating oil and graphite.

* *

How a Municipal Station Was Made to Pay

By JOSEPH A. JECKELL

SYNOPSIS—The author describes how he reorganized a municipal electric station which was losing money and made it produce current at the lowest cost in England. The plant is now paying over 13 per cent. on the capital invested and selling current at an average rate of 2.12 cents per kilowatt-hour.

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In 1901 the writer took hold, as manager and engineer, of the electricity works, a municipal undertaking, in the city of Coventry, England, having a population of 110,000.

This undertaking had been in operation six years and each year there was a loss after the capital charges had been paid, as in Britain the interest and sinking fund on the capital have to be met year by year and if not provided by the undertaking have to be put on the local taxes.

In 1901 the plant consisted of four Lancashire boilers, four compound jet condensing engines, driving by ropes; four single alternators, 87 cycles, 2000 volts generated, 200 volts distributed from substations. Capacity of plant, 550 kw.

The station was situated on a canal whence the condensing water was drawn.

Coal, 11,000 B.t.u., cost $2 per long ton. All mains were concentric and laid underground.

The gas works were also owned by the municipality and were a very flourishing concern, especially as nearly all the works in the city were driven by gas engines supplied by gas from the municipal works at 40c. per thousand.

The powerful gas committee, perhaps naturally, placed every possible difficulty in the way of pushing electricity sales, and as the gas undertaking was the "Old Love," the council took the same view and would not even allow the writer a salesman, so not to be beaten, he added these duties to those of manager and engineer and did the selling himself.

On taking hold the writer determined at once to change the whole system to two-phase, 50 cycles. Two-phase was chosen as thereby the single-phase mains could be utilized. Lighting was supplied single-phase and motors two-phase.

This necessitated scrapping the engines and alternators and a large proportion of the transformers and meters. It would have been more advantageous to have at once scrapped the boiler-house plant as well, but the committee would not hear of this. Britishers are not good scrappers. Moreover, owing to the timidity of the council, the work was only allowed to be done piecemeal and each addition had to be shown to have paid before the next one was sanctioned, thus delaying by several years the results eventually attained.

The writer decided upon the same kind of steam plant as he had installed at South Shields, where he had previously designed and erected the plant. This plant was triple-expansion, slow-speed, open-type vertical marine engines, surface condensing, direct coupled to the alternator and exciter. The air pumps and circulating pumps were driven from the intermediate crosshead, thus doing away with auxiliaries which are so frequently costly in steam consumption and upkeep. The cylinders were steam-jacketed.

In many stations there are found quite a number of different-sized engines and in not a few, different types of engines. In fact, some stations look like museums more than works for the efficient production of power.

The writer arranged to have all the engines the same type and same size. But as they would have to work on light loads as well as heavy, he looked for an engine which had a large range of economy and the above type was found to most nearly approximate his requirements. He specified that the steam consumption should be taken at ½ to ¾ and full loads and gave a bonus for each and every pound under the specified amount as the average of these three loads, but before deciding on this type he exhaustively tested the engines at various loads on the brake at the maker's works. He was the first engineer in Britain to install this type of engine for generating electricity.

Surface condensing was chosen as leaks can be so much better detected than when jet condensing is used.

The condensed water after having the grease extracted by chemical means was returned to the boilers.

A water softener was used to provide make-up feed, so that nothing but absolutely pure water was used, which is so essential if the best service is to be obtained from the boilers, especially with water-tube ones.

The coal obtainable was carefully tested and that which contained most heat per dollar was chosen. Grates and stokers were installed on the boilers suitable for this particular kind of coal. The writer found that by installing the grate and stoker most suitable he obtained an increased capacity of 17 per cent., and a decreased cost of evaporation of 54 per cent.

Six sets, 700 kw. each, of this type of plant were installed in the existing building with additional Lancashire boilers as the load required.

Afterward the writer designed a new station, 20,000 kw., with water-tube boilers, superheat, overhead bunkers, coal-conveying plant, etc., with 3000-kw. turbines, which was erected in sections as the demand for power increased.

The sales were pushed as much as possible, but due to the action of the gas committee in maintaining incandescent-gas mantles at a nominal price not so much progress was made in the direction of lighting as might have been expected. The force was, therefore, concentrated on the supply of power. Motors were kept in stock and loaned out with a fair purchase clause so that as soon as the customer was satisfied he was in a position to purchase his motor.

Slip-ring motors were used where the demand was small, but where it was considerable, a substation was built on the consumer's premises and he was supplied with squirrel-cage motors. Where possible, motors were installed with 2000 volts on the stator, thus doing away with the cost of transformers and the loss in them when the motors were idle.

Ordinary house wiring was not carried out by the electricity department, this being left to the contractors who were thereby induced to canvas for customers to the mains. The department, however, did the wiring for the motors as at first the contractors were not skilled in this work.

A special system of wiring, designed by the writer, was used whereby the cost of wiring was reduced one-third. This system was also passed by the Board of Trade for wiring to the motors.

Two single-phase meters were installed to each motor, thus only single-phase meters were stocked. This enabled a motor whose phases were not evenly balanced to be at once detected and it was replaced before a complaint was received. The writer considered that a satisfied consumer was the best canvasser he could have.

Financial Proposition

This was naturally the most important of all, as it was the crux of the whole situation, the main object being to make the undertaking a financial success, whereas up to 1901 it had been a ghastly failure. The first thing the writer did was to design a ledger which would show at a glance where the costs were too high, the accounts of all other undertakings being at the writer's disposal.

A ledger was designed, containing the Board of Trade headings, amplified as suited the special circumstances of the case. This ledger contained 52 weeks, 12 months, four quarters, two half years and a year, a page being devoted to each. The weeks were carried forward to the months, the months to the quarters, etc. The results for the current period were entered on the right-hand page, the last year's results being posted on the left-hand side, so that on opening the ledger anywhere the results of the current period could at a glance be compared with those of last year. This enabled the writer to keep an absolute check on the expenditure under each heading. The costs were worked out for each item to one five-hundredth of a cent per kilowatt sold.

The consumer's meters were read every three months and the ledger brought out automatically a balance every three months. This method of easy comparison, rendered possible by the ledger, enabled a vast number of economies to be carried out at the works, thus reducing the cost of manufacture considerably as is evidenced by the fact that the total cost, exclusive of capital charges, was $21,790 in 1901 for 341,810 kw.-hr. sold; and in 1904, was only $22,420 for 920,192 kw.-hr. sold.

As is usual in the British Isles, part of the books were kept at the electricity works and part by the city treasurer. Chartered accountants were called in and recommended that all books be kept by the writer. This method was adopted and thenceforth he kept all the books and prepared the balance sheets, all the accounts being audited by chartered accountants who conducted a continuous audit all the year.

Immediately a surplus was made, the rate payers clamored for a contribution to be made to the local taxes, as they had to raise so much money formerly to make good the deficit on the electricity works; $61,250 had been added to the local taxes to meet the deficit charged to the works. As a "sop to Cerberus," $5000 was paid to the taxes in 1907. This was increased gradually until this year $25,000 was paid over, the total to date being $86,500.

The writer, however, very strongly urged the building up of a large reserve fund, especially in view of the fact that there were a great number of liabilities standing in the books with no liquid asset to represent them. The outstanding debt on all plant scrapped by the writer, not provided by the sinking fund, was found out of revenue. This was sanctioned and the amount already placed to the reserve fund is $300,000.

In order to place the undertaking on an *absolutely* sound basis, the writer examined all the accounts, which had been charged to capital since the undertaking was started, and wrote off all those items not represented by a liquid asset. It was found that these totaled $135,000 Moreover, there was $200,000 worth of plant which might have to be scrapped before the time the loans granted for it were extinguished by the sinking fund, the original life allowed being too long, hence the extreme desirability of building up a reserve fund as rapidly as possible which could be used for this purpose.

The life of all parts of the plant was estimated, with the years run and the years to run, and it was found that at the then rate, the sinking fund would extinguish the loans many years before they would be liquidated by ordinary depreciation, though in the earlier years considerable sums might be required as aforesaid. This report received the unqualified approval of the special financial electrical expert of the British government. Doubtless the fact that the writer acted as manager, engineer, salesman and accountant worked for simplification and efficiency and by his methods of organization he found no difficulty in keeping in close touch with, and control of every detail from the calorific value of the coal to the balance sheet. His watchword was efficiency, brought about by organization, simplification and standardization.

The Board of Trade returns are given herewith. All electricity-supply works in Britain have to make these returns annually.

The operating costs at Coventry are now the very lowest in the British Isles, though there are 30 undertakings having larger outputs, the largest being Manchester with sales of 94,000,000 kw.-hr. per annum, and as these works supply energy to the street cars, they have a load factor of 25 per cent. as compared with the 20 per cent. load factor at Coventry, which does not supply the street cars.

Even with these advantages, the Manchester costs are 1.10c. per kw.-hr., viz., 66 per cent. above those at Coventry.

The following are the detailed costs of Coventry for 1912:

COSTS PER KW.-HR. SOLD

	Cents
Coal	0.26
Engine room stores	0.02
Wages, generating station	0.10
Repairs, generating station	0.04
Distributing wages and repairs	0.10
Management, salaries	0.06
Establishment charges	0.02
Rent, rates and taxes	0.06
Total	0.66

The profit earned on capital invested was the highest of any electricity-supply works in the British Isles, being 12.18 per cent.

For the year ending Mar. 31, 1913, the sales have increased to 13,337,482 kw.-hr., and the profit on capital to 13.04 per cent., the average price obtained being reduced to 2.12c. per kw.-hr.

The following is a summary of results obtained:

SUMMARY

Old Regime		New Regime	
Put on local taxes	$61,250.00	Given to local taxes	$86,500.00
Annual loss	11,250.00	Annual profit	92,170.00
Capital expended	379,065.00	Capital expended	$1,658,200.00
Cost operating per kw.-hr.	6.12c.	Cost operating per kw.-hr.	66c.
Cost per kw. installed	689.00	Cost per kw. installed	$138.00
Many accounts charged to capital which should have been charged to revenue		Many accounts charged to revenue which might have been charged to capital	
Surrounding districts assigned to a company.		Municipality granted power in surrounding districts.	
Yearly revenue	29,485.00	Yearly revenue	$298,430.00
No reserve fund		$300,000 placed to reserve.	
Gross profit on capital		Gross profit on capital	13.04%
Average for year	2.2%	Averaged for year	
Capacity of plant, kw.	550	Capacity of plant, kw. ...	13,000
Load factor.............	10%	Load factor............	20%

❖ ❖

New Continuous Chart-Recording Instrument

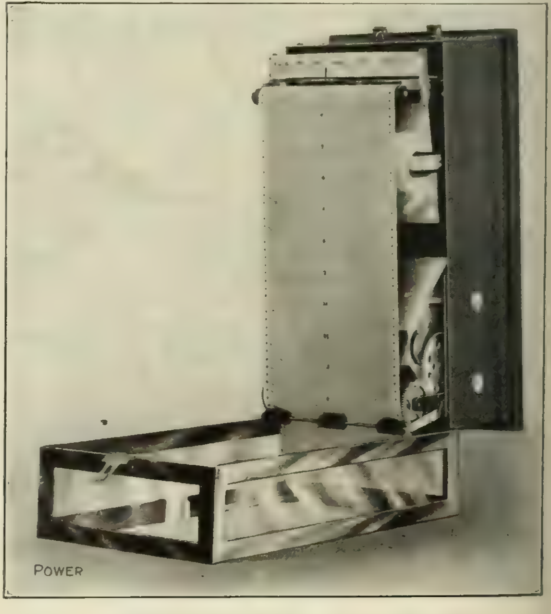
A new type of continuous-recording instrument for use as an electrical pyrometer for recording temperatures, and also as a recording voltmeter or ammeter has recently been placed on the market by the Brown Instrument Co., and the Keystone Electrical Instrument Co., Philadelphia, Penn. The instrument is simple in construction and compact in form. The case is 15 in. high by 8 in. wide, and projects from the switchboard or wall 7 in. The space occupied by the instrument has been largely reduced by placing the clock mechanism behind the record chart instead of to one side, and the record chart is the only part shown on the face.

A two-months' roll of record paper is used. It is necessary to wind the clock once a week. The complete instrument with a record on the recording chart is illustrated herewith. One scale is placed above the record so that the indications are visible at all times, and the scale is printed on the paper for direct reading.

The paper runs over a table at the top and is driven by a clock mechanism, the paper rolling out from the bottom of the instrument. A ribbon similar to those used in typewriters passes over the record paper and a mechanism depresses the pointer against the ribbon, which, in turn, is depressed against the record at intervals as desired. Dots forming the record can be made from 5-sec. up to 1-min. intervals.

Record paper can also be had with a coated surface, which does away with the ribbon, and the pointer striking the paper makes small dots on this coated surface. This is a specially prepared paper of patented form which requires no fixitive solution to preserve the record, and while the record is legible the paper cannot be smeared in handling.

This continuous-recording instrument will prove particularly advantageous for use as an electric pyrometer in conjunction with thermo-couples, for resistance thermometers for measuring low temperatures, or for recording volts or amperes. As the d'Arsonval frictionless type of direct-current instrument is used to prevent lag in the readings, a sensitive and accurate instrument is secured



Continuous Recording Instrument

Editorials

New York State to Economize on Coal

Suppose a corporation using approximately 320,000 tons of coal a year at $3.50 per ton were to effect by intelligent purchase a saving of 25 cents per ton. This would amount to $80,000 per annum—an item worth striving for.

Although the conditions of price and saving as given above are not true of the purchase of coal by the State of New York, the coal consumption of its various institutions is approximately the figure stated.

One of the channels through which Governor Glynn hopes to effect economy is that of the purchase of coal by specification for all state institutions. Heretofore, the purchasing committees of the various state departments have each purchased coal in its own sweet way. These committees have formed themselves into a joint committee to purchase coal for all institutions. The coal will be bought in large amounts, and distributed to the various departments as required. This should result in considerable saving, as those in charge of most of the state departments are physicians who have little knowledge of the importance of the quality of fuel to say nothing of approved methods of purchase.

About two-thirds of the coal used is anthracite. All coal will be bought by specification and on a heat-unit basis. The ton, both long and short, has been eliminated, and the unit of weight on which the heat value and price is based is 1000 pounds. No limit has been placed on the moisture content, Charles G. Armstrong, of New York City, who drew up the specification, claiming that this is something the miner or dealer cannot well control. For all the anthracite grades, the allowable limit of volatile combustible is 30 per cent., and the limit for sulphur is two per cent. The limit in percentage for ash is 11 for broken and egg, 12 for chestnut, 17 for pea, and 18 for No. 1, 19 for No. 2, and 20 for No. 3 buckwheat grades. Twenty-two per cent. ash is allowed in slack and refuse. The lowest allowable heat values vary from 13,400 B.t.u. for broken and egg, to 12,000 for No. 3 buckwheat. For soft coal (run of mine and lump chestnut) the allowable limit of volatile matter is 30 per cent; that of sulphur, 2 to 2½ per cent., and for ash, 10 per cent. for all grades of soft coal.

The advantage claimed for the allowable high volatile ontent in soft coal is that it broadens the field of availble supply, and will, therefore, create keen competition or the state's coal business.

Three seven-pound samples of each shipment will be aken; one will go to the contractor or dealer, one to the hemist, and one will be retained for the determining nalysis in case of dispute by dealer or user. In case of lispute, the Bureau of Mines, at Washington, will make his analysis which shall be final. Dealers will be penalzed for shipments inferior in quality to that specified, nd will receive a bonus when the quality is better than alled for.

In addition to the saving realized from more intelligent methods of buying, there are other possibilities for saving: Nearly all of the state plants now using egg and chestnut coal can use broken coal with equally good results. The latter grade of fuel costs about 50 cents per ton less than chestnut and 25 cents per ton less than egg and stove. By using much more broken coal an appreciable saving will result. Many of the state buildings are in comparatively isolated places, and the boilers of many have stokers or Dutch-oven furnaces. Coal of high volatile content and of proportionately lower cost may, therefore, be used without producing objectionable smoke.

The state should follow up this work by further economizing in the use of fuel by making slight corrections in the boiler-room practice. Leaky settings may be repaired and the firing methods changed to advantage. Mr. Armstrong claims that with proper attention to boiler-room practice in connection with the intelligent purchase of coal, a saving of at least $250,000 a year may be realized.

What state will be next to follow New York in this plan?

Pass It On

Look over the trade periodicals on your desk this morning; also step out in the back room where you keep your office supplies and take stock of the publications you have piled away for future reference. There must be quite a stack of them out there gathering dust and occupying much needed space. How many times have you gone into that supply room to run through the back numbers and dig out an article you recollect vaguely of having seen some time or other? Not very often; have you?

Again consider those magazines just laid on your desk among the morning's mail. Do you go through them carefully? The chances are that when you pick up one, you turn the pages quickly, noting only the illustrations, until you come to an article bearing on your own particular product. This you skim over hastily, or digest carefully, as the importance of your correspondence allows. Again you move along rapidly, stopping a moment to note market quotations, until finally you toss the magazine to the back of the desk, with the mental remark that you will look through it again when you have more time.

How many men in your organization, or under your orders, ever see that paper to which you can spare only a scant quarter of an hour? Many of those men are ambitious; some are real thinkers. They may need only the word picture of how other men are solving problems common to your business to start them to thinking about the unconquered difficulties right in your own plant.

More than one great manufacturing organization of the present day owes its success to the discovery of the simple truth that the more brains there are focused on certain problems, the better chance those problems have of being quickly and surely solved. Trade books and publications so disposed that they can be looked over and their articles of interest discussed during leisure moments, such as the noon hour, make one of the best ways of awakening interest in the work at hand.

Did you ever think of the tremendous amount of labor required to analyze the latest developments and ideas in a particular field; to investigate the newest apparatus and processes; in short to produce a useful, readable business magazine? That periodical into which you look for a few moments contains the best thoughts of a score or more of men who are top-notchers in their lines.

Has your business got all the benefit possible out of that magazine which you will soon lay aside to continue the morning's dictation? Cannot some of those men, on whom you rely for the smooth and noiseless operation of the business machine, glean one more idea from its pages? Even one useful idea may mean thousands of dollars in plant economies or improved product.

Therefore; for the inspiration of your men and the advancement of your business; after you have read your trade paper, *pass it on.*

* * *

The Operating Engineer

Workmen of all trades are required to serve a certain apprenticeship before being given the stamp of efficiency. If a brick-mason, a machinist or a carpenter is needed for a certain piece of work, one is selected who has fulfilled the apprenticeship requirements, and a more or less satisfactory piece of work can be expected. The position held in the commercial world by the stationary engineer is unique. If an engineer is needed, how different the method of procedure! His efficiency depends entirely upon himself, and not upon a certain period of apprenticeship.

Many an engineer, after years of service in one plant, fails miserably in another. Why? Because he has not fitted himself for any position other than the present; he has become an automaton, with no thought of the future.

On the other hand, consider the progressive engineer. He keeps uptodate and is vastly different from the majority of men found in the trades, although, in nearly all cases, they are better paid. This engineer is looked up to; he is held in respect in the large office buildings. This is but just, for in what other profession is the member required to keep so well informed to meet its constantly changing conditions.

What are his prospects for the future? We are entering upon a stage where the concentration of power has its adherents as being the more economical. If such is true, then what of the future of the engineer? The fact that large stations, in a great many instances, can furnish light and power cheaper than can the isolated plant has not and can not prove the bugaboo to the operating engineer as some think.

In what respect will an employer hold his engineer if he will present an impartial report concerning the adoption of central station power, instead of waiting for the central station expert to do it (as he will)? Consider the two positions of the engineer under such conditions. Which engineer "sticks?" Which engineer is promoted to manager or superintendent? Surely not the one who waited.

The stationary engineer of the future need not fear the encroachments of the central station, for the results show that a better position awaits him.

* * *

Engineers and Engineers

In the correspondence columns of our March 10 issue, Victor Bonn submits a comment upon an editorial entitled "One-sided Development," which appeared in one of the August issues of POWER. The theme of the editorial in question was that professional people are so much absorbed in the details and intricacies of their subject, that they do not develop good selling ability for their own services, and that many of them employ others to conduct this business for them. Applying this condition to the engineer, the editorial read:

> This arrangement among professional people has its lesson for the engineer. The competent, efficient power-plant engineer must have today enough book knowledge to entitle him to a place in professional ranks In order to acquire this knowledge, he devotes all his spare time and energy to study and experiments along the one line—engineering to the exclusion of thought and culture along other lines, including the art of conducting business.
>
> No wonder, then, that he is underpaid, which means simply that he has not, as a rule, acquired the business ability needed to sell his own services at a price which represents their real value.

Mr. Bonn suggests that it is equally necessary to educate the employer to safeguard his interest by employing a really competent engineer, which is all too true. The power-plant engineer—and we mean here, the real engineer, with that combination of knowledge of principles and experience in its application which is truly professional—is a development of the past few years, and power-plant owners generally have not come to differentiate him from his prototype, who was simply a more or or less skilled mechanic. The observation does not apply to the man, who, as Mr. Bonn says, drifts into firing because he can make a couple of dollars a week more than a common laborer, and is after some years promoted to run the engine with a little raise in pay. Such a man can, by study and an intelligent use of the opportunities afforded by his situation, make an engineer of himself in the sense in which the term engineer was used in the editorial; but he is not such an engineer simply because he turns steam into and squirts oil at an engine.

Some time ago, there came an impatient 'phone call to the editor: "What kind of a man was that you sent down to me?"

"That was a thoroughly good, reliable Corliss egineer."

"Yes, I haven't any doubt that he could run our engine all right, but we want a man who can run the plant."

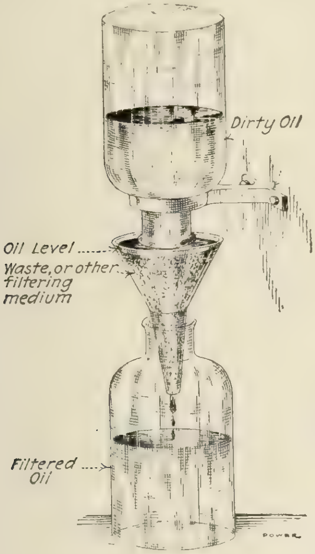
A striking instance of the difference between an engineer and an engine runner is afforded by the experience of a friend of and contributor to POWER, who less than a year ago, accepted a position as engineer of a company having a number of plants. Instead of losing himself in the petty details of the situation, he got out his note book and pencil, inquired into the amount of coal that was being used, the work that was gotten out of it, the price that was paid for it, the source of its supply, the number of boilers, square feet of grate surface, etc., that was used to burn it, with the result that by a change of supply and method of use, he effected a saving of over $100,000 per year and had his salary doubled before he had been with the company eleven months.

Correspondence

A Simple Filter

A simple and easily made filtering device that can be used for taking dirt or other solid substances out of nearly any kind of liquid is herewith illustrated. It is made on the "water-bottle principle."

Two bottles, a funnel and some waste are all that that are needed, or one bottle, a funnel and a pan would do as well. Charcoal or any other filtering material commonly used can be placed in the funnel.



OIL FILTER

S. F. WILSON.

New York City.

Hickory as Cylinder-Head Material

Frequently the man who runs a mill or factory is called upon to meet emergencies that make him think hard to figure the best way out of the difficulty.

A case of this kind came up not long ago. The cylinder head of an engine furnishing power for a lumber plant blew out, and it stopped operations immediately. To make matters worse, several rush orders for lumber were on hand and it was imperative that the plant be put n operation again at the earliest possible moment.

The superintendent packed the broken cylinder head and shipped it by express to a machine shop located in near-by city, with instructions to rush a new head back t once. He was informed that it would be four or five ays before shipment could be made as the head would ave to be cast.

It was impossible for the plant to remain idle for that length of time, and the engineer realizing the necessity for getting up steam again as quickly as possible, suggested that a temporary head be made out of a piece of hiskory. The superintendent laughed at the idea but finally decided to try it.

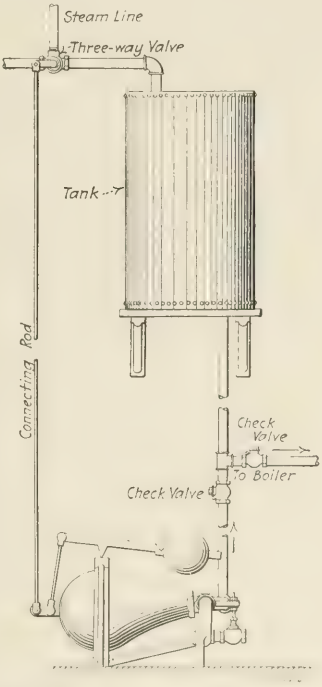
A piece of well seasoned hickory about 3 in. thick was shaped and drilled and bolted on the cylinder. The hickory head was used on the cylinder until a new cast head could be got from the machine shop, and it was then taken off and laid aside to be used for future emergencies.

G. M. RITTELMEYER.

Jackson, Miss.

One Trap Does Work of Two

This sketch illustrates how one return steam trap can do the work of two in feeding low-pressure drips or open heater water into the boilers and can be used under any pressure high or low. The arrangement consists of an ordinary return trap which discharges into an elevated tank of about equal capacity*. The tank should be elevated sufficiently to give a slight static head over the water in the boiler. A three-way valve or its equivalent alternately admits and releases the steam to and from the tank in the same manner as in the trap, but the reverse order in point of time. In the illustration the valve is



TRAP CONNECTED TO DO WORK OF TWO

operated by the return tilt trap by means of a light rod or other suitable arrangement. This is convenient when the tank can be located directly above the trap but the tank may be located at any suitable point and the three-way cock located at or near the trap and connected to the elevated tank by a small steam pipe. The check valves in the figure open in the direction of the small arrow. If applied to a stationary or nontilting trap a small steam pipe is connected from the top or steam space of the trap to a diaphragm-operated three-way valve which takes the place of the type of valve first described.

The action in this case is as follows: When the steam pressure is on the trap in the act of discharging the water from it, the same pressure is on the diaphragm, closing the steam valve and releasing the pressure from the tank so that the water from the trap meets no resistence therefrom, but as soon as the trap is emptied and is relieved of the steam pressure the diaphragm of the valve is also relieved of pressure and the valve opens the steam line, thereby admitting steam pressure above the water in the tank and discharging it into the boiler. The diaphragm-valve construction is, of course, also applicable to a tilt trap. In either case there is no difficulty in feeding high-pressure boilers for the reason that only the packing of the one small three-way valve is subject to high pressure, a fact that will be appreciated by all users. Since there is no motion or vibration the tank may be placed on any support which will carry its weight or even suspended from the ceiling of the roof at a considerable elevation above the return trap which elevation will hasten its discharge.

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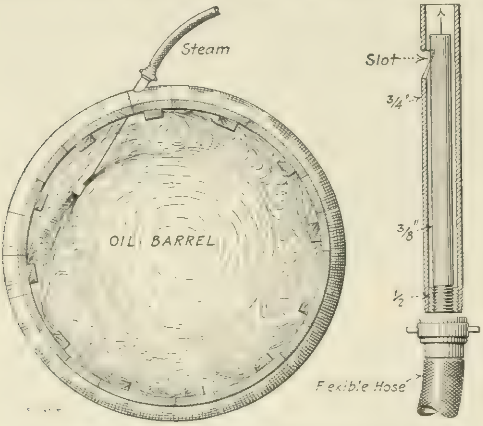
*The engraving unfortunately shows the tank much larger than the trap. They should be, as our contributor says, "of about equal capacity." Otherwise the steam used to discharge the water from the tank will be excessive in proportion to the amount discharged.

LEON LEWIS.

Washington, D. C.

Steam Washer for Cleaning Overalls

The accompanying sketches show an arrangement a fireman in our plant made for washing overalls after considerable experimenting with several similar ideas, none of which was so satisfactory as this.



PLAN OF WASHER AND SECTION OF NOZZE

The outfit as shown consists of a barrel with an injector-like apparatus which may be connected to a steam main through a flexible hose connection. Around the sides of the barrel is a series of vertical slats to break up the steady rotation of the water which the injector action gives and to set up counter-current, so that the clothes to be washed are thoroughly agitated.

The barrel is an ordinary oil barrel; the injector was built up of three standard sizes of pipe assembled as shown in the sketch.

ARTHUR S. WELLS.

Ithaca, N. Y.

Broken Cylinder Patched

Figs. 1 and 2 show how the cylinder of an engine was damaged by a follower bolt working loose and being jammed between the cylinder and piston. The cylinder head was also broken. It was at first thought that a new cylinder would have to be purchased, but a good repair was made to the broken one by patching it.

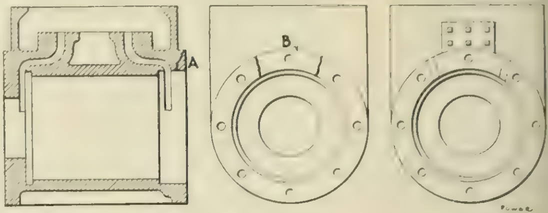


FIG. 1 FIG. 2 FIG. 3

SHOWING CRACK AND MANNER OF REPAIR

A pattern was made and a brass patch cast. The end of the cylinder was dovetailed to receive the patch shown in place in Fig. 3. The patch was coated with a mixture of red lead and oil and tried in the cylinder to get impressions for making a steam-tight fit. After the face of the steam chest was drilled and tapped the patch was driven in place and bolted. A portable boring bar was used to face off the parts after the patch was bolted on. The patch was calked around the joints and has served its purpose without trouble.

ROBERT P. HARRIS.

Washington, D. C.

Position of Joints in Snap Rings

It would seem that if snap rings were made a good fit in their grooves, and a good fit to the cylinder, that they should work equally well with the joints in any position, whether it be at the top, bottom or side of the cylinder.

Such is not the case, however, especially after the piston is worn; at least, this has been my experience. The piston in one cylinder of a two-cylinder, single-acting twin, gas engine leaked badly. It was supposed that a ring was broken, but when the piston was removed, the rings were found to be in good condition. Neither could anything be noticed that would account for the leakage. There was a clearance mark on the piston rod and when the piston was replaced, care was taken that the rod was screwed into the crosshead until this mark was in proper position. On starting again, the blowing had ceased, but after a short run it developed again.

The engine was stopped and an examination showed that the piston and rod had turned so the joints in the rings faced the side of the cylinder instead of the bottom. After correcting the position to check with the original marking and locking the rod securely in this position, no further trouble was experienced.

I had noticed that the joints in the snap rings of horizontal gas-engine pistons were always placed on the bottom of the cylinder and I was careful after cleaning to put them in that position, but I had never thought that this location of the rings would make so much difference in their functioning.

Upon reflection it is plain why this condition should be. The weight of the piston holds it to the bottom of the cylinder and the rings lie completely in their grooves at the bottom of the cylinder and out in the grooves as far as the cylinder will let them, at the top.

This being so, it can readily be seen that when the joints are at the bottom, they are subject to very little pressure, as the piston makes a close fit with the cylinder walls on the bottom, and the rings make a close fit with the cylinder walls on the sides and top. If the joints were placed on top, a path would likely be found through the joints.

Earl Pagett.

Coffeyville, Kan.

⁂

Plant vs. Purchased Power for Department Store

I noted in the issue of Jan. 27 the report by F. W. Rose, showing the costs in a department store operating its own plant as compared with purchased power. The costs for central-station service are given but there is no note of the kilowatt-hours furnished or any other information which will enable a proper comparison to be made. Furthermore, the maximum load on the plant under central-station service and with the isolated plant is not given. This is important in comparing total costs for service.

In Table 2 the expenditures for a year, which includes part of 1912 and part of 1913, are given and there appears to be some marked discrepancies. Take the item of coal cost per kilowatt-hour generated. This varies widely as shown by the following which I have calculated from the data given:

Sept. 1912, coal cost = 2.35c. per kw.-hr.
Oct. 1912, coal cost = 1.62c. per kw.-hr.
Nov. 1912, coal cost = 2.36c. per kw.-hr.
Dec. 1912, coal cost = 1.05c. per kw.-hr.
Jan. 1913, coal cost = 1.51c. per kw.-hr.
Feb. 1913, coal cost = 2.76c. per kw.-hr.
Mar. 1913, coal cost = 2.39c. per kw.-hr.
Apr. 1913, coal cost = 1.26c. per kw.-hr.
May 1913, coal cost = 1.03c. per kw.-hr.
June 1913, coal cost = 2.61c. per kw.-hr.
July 1913, coal cost = 0.89c. per kw.-hr.
Aug. 1913, coal cost = 1.98c. per kw.-hr.

Note the wide variation of these costs from 0.89c. to .76c. and apparently the coal cost bears no relation whatver to the load on the plant.

The statement is made that only one 200-hp. boiler was sed at any time in the operation of the plant. Assumng this to be correct and that the resultant maximum lectric load would not be over 200 kw., the published rate heet of one of the large city plants can be applied to his installation. Under this rate schedule referred to, customer for 200 kw.-hr. of maximum demand can obtain 378,330 kw.-hr. during the year for the net sum of \$10,387.47; an average rate of about 2¾c. per kw.-hr. The foregoing calculation is for standard low-tension direct-current service. If low-tension alternating service could be used, the annual charge would be at least 10 per cent. lower than the amount stated.

In the cost statement noted in Table 3, the average cost per kilowatt-hour for the same number of kilowatt-hours annually, figures out 4.37c. per kw.-hr.

In view of this comparison, it seems that considerably more information is required in order to show any particular saving through the ownership of the isolated plant in question, particularly if the fixed charges are made up on a proper basis instead of simply at legal interest rates.

G. E. Wendle,
Lycoming Edison Co.

Williamsport, Penn.

In reply to the criticisms of Mr. Wendle, I wish to take them up in the order in which he has made them:

1. Kilowatt-Hours of Central-Station Service—No mention was made in the original article of the kilowatt-hours used from central-station service, because the only year in which the comparison would have been at all of value was the first year, and that year the current was purchased under a flat rate, and for the other years the current used from central-station service was just enough to keep above the minimum charge for the emergency connection.

2. Maximum Load—No records have been kept of the maximum load, but at no time with the Saturday-night load, or during the holiday season when the store is open evenings, is the 200-kw. unit overloaded. Ordinarily, the smaller unit carries the load, which much of the time is more than full-load rating of the generator, often a momentary overload of 75 per cent.

3. Coal Costs—The items under "cost of coal" were taken from the books of the company as the bills were paid. This will account for the apparent discrepancy, for it does not follow that the coal paid for in any one month was used in that month.

The high coal cost for the year 1910-1911 was due to 24-hr. service being maintained for nine months, or until the emergency service was connected, and for a number of weeks during that time the small generator was out of commission and it was necessary to run the large unit, which was uneconomical on the small loads.

Another item which was omitted in publishing, was that the plant supplied high-pressure steam and hot water for two kitchens in the store.

4. Cost per Kilowatt-Hour—In figuring the cost per kilowatt-hour, Mr. Wendle has not taken into consideration the fact that this plant also furnishes heat, ventilation, live steam for the kitchens and hot and cold water for all purposes, and that in the total costs of operation are included the maintenance of all the above items as well as of the plumbing and of an automatic sprinkler system for the entire store.

In the original report no attempt was made to figure the cost per kilowatt-hour, as in a proposition of this kind it is practically impossible to separate the various items so as to arrive satisfactorily at the correct cost per kilowatt-hour.

If the cost per kilowatt-hour were figured by taking the "Cost Less Purchased Current" for the year 1912-1913, and take from this the corresponding cost for the year 1909 1910, then the charge against the current would be $6581.61, which is 1.21c. per kw.-hr. This figure, which is not absolutely correct, is much nearer the cost than the 1.37c. as figured by Mr. Wendle.

The only satisfactory way of arriving at comparative costs where the generation of electricity is a byproduct, so to speak, is to take the total costs of the power department.

5. Fixed Charges—I will not enter into a discussion of the fixed charges, as there is a great difference of opinion on this subject, but there are a large number of business houses which recognize this as a factor, but do not carry more than 12 per cent. on their books, and some not as high as that.

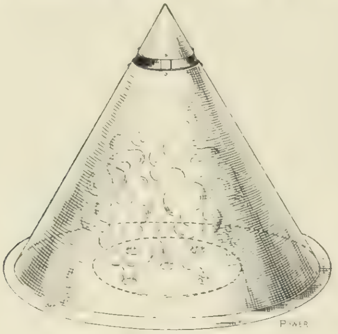
F. W. Rose.

Minneapolis, Minn.

* * *

Eliminating Steam Vapors

Steam has a disagreeable faculty of showing itself conspicuously to the detriment of the prestige of the engineer-in-charge. One particular place is at manholes on long underground systems, such as are used in the streets of cities, and the grounds of large public and private institutions, causing comment and criticism which is not often just. At the present time, there does not appear to be any system of joints which will remain absolutely tight after a year or so of service, especially where right-angle joints occur, and it would be foolish to endeavor to remedy the matters by taking up and relaying the system. The best thing for the engineer to do is to eliminate the steam where it occurs, and this can be done by building copper casings over them as shown in the illustration. An opening is provided near the top, as if a small section or frustrum of the cone were removed. The manner of securing this casing or hood in place will depend upon conditions, but in most instances it is preferable to securely fasten it to the surrounding construction, and not removably so, that is, simply fastening it to the manhole cover is not desirable.



Steam Condenser over Manhole

This arrangement will effectively condense the vapors and steam coming into the manhole and trying to escape through the casing, mainly because a large cooling surface is provided and arranged so that all the steam must make contact with it. The opening at the top serves to provide ventilation for the manhole, to permit air to circulate in the casing and thereby keep it cool, and also to provide an arrangement whereby the coolest part of the device is in the best location. The casing also provides a relatively large surface for the wind or outside air to cool.

It is preferable that the casing be made of copper because of its longevity and also because in aging it becomes a green color which makes it less conspicuous on grass. Bent tin or galvanized iron would in many cases be just as suitable. The arrangement is one which can be modified to suit other places where it is desired to condense steam and will always be found to be effective.

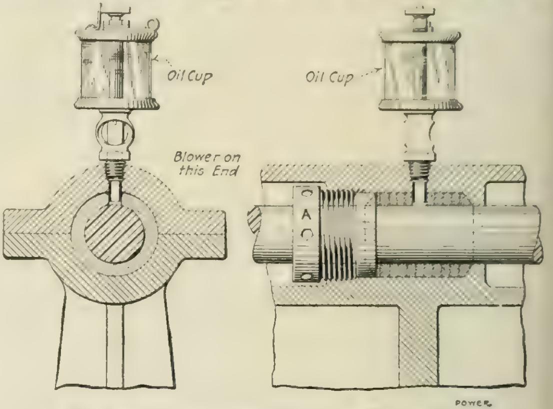
A. P. Connor.

Washington, D. C.

* * *

Lubricating Turbine Packing

A steam turbine-driven blower set had been installed in place of the belt-driven blower formerly used for draft. The turbine company by its contract sent a man every six months for a year and a half to examine the turbine. One of the things which he did each time was to pack the two stuffing-boxes—one on each side of the unit. A continuous shaft passed the entire length of the set so that one stuffing-box came between the turbine and the blower.



Oil Cup to Lubricate Turbine Gland Packing

This stuffing-box is shown in the sketch. The packing inclosing the shaft revolving at high speed, needed lubrication which was furnished by a large oil cup set into the cast-iron cap having a $\frac{3}{16}$-in. hole leading from it to the packing space.

The factory men always furnished their own packing and never informed the attendants as to its kind. After the contract had run out, the attendants had occasion to pack the stuffing-boxes and put in piston-rod packing such as was used on other engines. The stuffing-box on the free end of the shaft never gave trouble, but the inside one was an annoyance from the start.

To remedy the trouble a larger oil hole was drilled and a piece of brass tubing driven in, projecting through so that it just cleared the shaft. The back end of the stuffing-box was packed in the usual manner, then two loops were cut short and the gap between the ends brought to the top. In this gap the tube extended and carried oil to the shaft. The oil then fed satisfactorily.

D. A. Hampson.

Middletown, N. Y.

Inquiries of General Interest

Coking Fire—What is meant by a coking fire?

J. G.

One which is stoked at the front and the coal shoved to the back when it has become coked.

Trying Safety Valve—How often should a boiler safety valve be raised?

J. C.

To be assured that the valve has not become stuck on its seat, the valve should be lifted or caused to pop at least once every shift.

Use of Mechanical Stokers in Marine Service—What difficulties are in the way of using mechanical stokers on steamships?

E. T. D.

The principal difficulties to be encountered are in the arrangement of conveyors, lack of sufficient deck space and head room and disturbance of the fire from the motion of the vessel.

Trouble with Rope Drive—In starting up a rope drive with slack ropes, the ropes run out of the grooves of the guide shieves used for changing the direction of the ropes. What may be the cause and remedy?

L. I.

The trouble may arise from delivery of the ropes on the pulleys at different inclination to the planes of the pulleys than when the ropes are running under tension. The remedy probably would be to favor the sag by adjusting the pulleys to positions which are more nearly vertical.

Crumbling of Firebrick—What would cause crumbling and spawling of the firebrick lining of a furnace?

J. W. D.

Crumbling may be due to water contained in the firebrick when laid, or to their having become wet, or to absorption of moisture from the walls or the atmosphere when the boiler has been out of use. Spawling and also cracking of furnace walls may result from sudden cooling of the walls by leaving the furnace or draft doors and damper open when the fire is so low as to allow the walls to cool down too quickly.

Disinfecting by Steam—How is steam used for the disinfection of bedding, etc., and what form of apparatus is used?

J. A. G.

The heat of steam is used for disinfecting both by direct application of live steam and sterilization by radiation of heat. The special apparatus employed for the purpose, and which is known as a steam sterilizer, usually consists of a horizontal shell of boiler plate surrounded by a steam jacket space, and with a steam-tight door at each end. In the best forms provision is made for introducing steam to the interior and after sterilization is completed and the supply of steam has been cut off from the interior, moisture is carried off by a steam-jet exhauster while heating by the steam jacket is continued.

Greatest Movement of Valve.—With a shaft 15 in. in diameter and an eccentric of 5-in. throw, what is the greatest distance a valve could be moved by turning the eccentric ⅛ in. on the shaft?

W. H. C.

The throw of the eccentric being 5 in., its eccentricity would be 2½ in., and the shaft being 15 in. in diameter its radius would be 7½ in. The movement of the eccentric around the shaft, through a circumferential distance of ⅛ in., at a radial distance of 7½ in. if measured on the circumference of the circle having a radius equal to the eccentricity of the eccentric, would be

$$\frac{\frac{1}{8} \times 2\frac{1}{2}}{7\frac{1}{2}} = \frac{1}{24} \text{ in.}$$

and this would be practically the greatest distance a valve could be moved under the conditions stated.

Brake Horsepower of an Engine—What is the formula for computing the brake horsepower of an engine when using the prony brake?

J. H. C.

The formula is:

$$\text{brake horsepower} = \frac{2\pi \times L \times N \times P}{33{,}000}$$

in which

$2\pi = 2 \times 3.1416$, or 6.2832;

L = The effective length of the brake arm in feet, being the perpendicular distance from the axis of rotation of the brake wheel to the line of resistance measured;

N = The number of revolutions per minute made by the brake wheel;

P = The net resistance in pounds at the distance L from the axis of rotation of the brake wheel, while making N revolutions per minute.

Formula for Flow of Steam Through Pipes—What is the formula for the flow of steam through pipes?

S. E. B.

Unwin's formula, which has been accepted after extensive tests, is as follows:

$$W = 87.5 \sqrt{\frac{P y d^5}{L \left(1 + \frac{3.6}{d}\right)}}$$

in which

W = The flow, in pounds per minute;

P = The difference between the steam pressures in the entrance end and discharge end of the pipe, in pounds per square inch;

y = The density or weight per cubic foot of steam of the pressure at the entrance (to be obtained from the steam tables);

d = Diameter of the pipe in inches;

L = Length of the pipe in feet.

Reasons for Back Pressure—What are the reasons for back presure on an engine?

S. U.

Back pressure occurs from any cause which prevents the exhaust from reduction to zero pressure, or perfect vacuum, and may be due to one or more of such causes as: leakage of the piston from the pressure side; leakage of the admission valve during the return stroke of the piston; insufficient opening of the exhaust valve; closure of the exhaust valve before completion of the return stroke; contracted exhaust passages; insufficient size, obstructions, fittings and friction of the exhaust pipe; hindrance to free discharge through feed-water heaters or into an exhaust heating system; exhaust steam from steam pumps or other engines discharging into the same exhaust pipe or receiver; mingling live steam with an engine's exhaust for assisting an exhaust supply to a heating system; back pressure of the atmosphere when working noncondensing; friction of exhaust passages to a condenser or through a surface condenser, and imperfection of vacuum obtained when working condensing.

Conductivity of ½-In. and 1-In. Plates—What would be the practical difference in efficiency of conductivity of heating surfaces of a boiler whether composed of plates or tubes ½ in. thick or 1 in. thick carrying 150 lb. pressure?

A. C. L.

In operating a boiler under 150-lb. gage pressure the temperature of the water is 366 deg. F., and assuming the average temperature of furnace and flue gases as 1200 deg. F., the average temperature difference between the water side and fire side of the heating surfaces would be about

$$1200 - 366 = 834 \text{ deg. F.}$$

It has been determined from experiments on the transmission of heat through plates of various thicknesses and allowing 10 sq.ft. of boiler surface per horsepower, that the necessary rate of transmission of heat through heating surfaces ½ in. thick would require a difference of temperature of 12.8 deg. F., and for heating surfaces 1 in. thick, a difference of temperature of 25.6 deg. F. These differences are so small compared with actual conditions as to indicate that the conductivity of boiler plates and flues of the thicknesses ordinarily used, is practically the same for all thicknesses.

Engineers' Study Course

Elementary Mechanics--I

The purpose of this section of the course, as of all that have preceded it, is to give a working knowledge of the fundamentals of mechanics sufficient for all practical needs. For this reason, only an elementary discussion of mechanics will be attempted.

To begin with, a few definitions will be given to fix the meaning of such terms as will be used from the start, then will follow simple explanations of the principles involved and practical applications of these principles will be given as examples or exercises, which will be made as pertinent as possible to power-plant problems.

To the average person the application of a principle is more interesting than a mere understanding of the principle by itself. For this reason the first few lessons, which will deal with definitions and statements of laws, may seem rather dry, but the student is urged to follow closely these introductory lessons so that he may more readily grasp the applications that will come later. Many will find that much of the early part of the course is familiar to them, but to others there will be new terms or at least new light on their meaning.

DEFINITIONS

Mechanics is that branch of science which has to do with forces and their action on bodies tending to produce a state of motion, change of motion, or condition of rest of these bodies. At the outset it is essential that the student clearly understand that he is concerned only with forces and that all bodies will be considered as rigid, irrespective of the forces acting upon them.

The study of forces is divided into two general subjects, *kinetics* which deals with the forces that produce or change the motion of bodies and *statics* which deals with forces that keep a body at rest or in a state of equilibrium. The term *dynamics* is commonly used to include both kinetics and statics.

Force is that which produces, or tends to produce, motion or change of motion of bodies. It manifests itself to the feelings by a tension or pull, and by a compression or push. In other cases it manifests itself by an attraction or repulsion. Assume a man pulling on a rope—it is evident that the man can exert no pull on the rope unless the rope be attached at the other end to a resistance. An engine remains at rest on its foundation only because the foundation exerts an upward pressure equal to the weight of the engine. Stated in the familiar law of Newton, *"to every action there is an opposite and equal reaction."* Hence no single force can be exerted without there resulting an equal and opposite reaction. Another example is that of the pressure of the steam in a steam boiler. Suppose the steam pressure in the boiler is 100 lb. per sq.in. This means that on every square inch of surface in the boiler there is a pressure of 100 lb. The reaction is furished by the material of the boiler, which, by virtue of its strength for each square inch is exerting a force of 100 lb. in resistance to rupture.

Gravity is the force by which all bodies are drawn to the earth. The force with which the earth attracts any body is called the *weight* of that body. Weight must not be confused with *mass* which will be discussed in a later lesson.

The unit of force is the weight of one pound or simply the pound.

Forces are represented graphically by straight lines; the *direction* of the force by an arrowhead placed at the end of the line and by the angle which the force makes with a given reference line; the *magnitude* of the force by the length of the line. Three things are then necessary to completely determine a force:

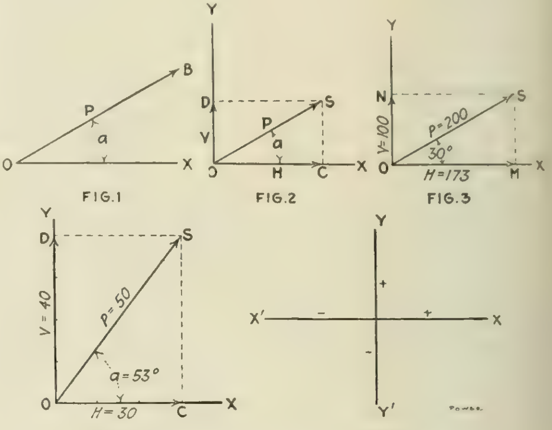


FIG.1 FIG.2 FIG.3

FIG.4 FIG.5

GRAPHIC REPRESENTATION OF FORCES

(1) The point of application of the force.
(2) The direction of the force.
(3) The magnitude of the force.

In Fig. 1, *O* represents the point of application of the force *P*. The angle *a* gives the direction of the force with respect to a horizontal reference line *OX*, and the arrowhead at *B* indicates that the force is acting from *O* to *B* and not from *B* to *O*. The length of the line *OB* indicates the magnitude of the force *P*. Thus if 1 in. of length represents 50 lb. and the line *OB* is 2 in. long, then the force is

$$P = 2 \times 50 = 100 \ lb.$$

COMPONENTS OF FORCES

The effect of a force in any given direction is called the *component* of the force. For convenience in dealing with problems, forces are generally resolved into their horizontal and vertical components. The component of a force can never be greater than the force itself and no force can have a component at 90 deg. to the line of action of the force. It must be evident, then, that a force exerts its maximum effort in its own line of action.

When an engine is on dead center the pressure of the steam on the piston has no component tending to rotate the crankpin for the simple reason that at the given instant the motion of the crankpin is at right angles to the motion of the piston.

A force may have an infinite number of components. These components may be determined either graphically or by the aid of equations.

In Fig. 2, let OX and OY represent the horizontal and vertical reference lines drawn through the point of application O of the force P. Let the length of the line OS represent the magnitude of the force P. The components of the force P are found graphically as follows: From the point S drop a perpendicular SC onto the line OX forming the intercept OC. The length of this intercept OC is the horizontal component of the force P. In like manner the length of the line OD represents the vertical component of the force P. It would be possible to find other components of P, but for the present only horizontal and vertical components will be considered. Let

H = Horizontal component OC of the force P;
V = Vertical component OD of the force P;
a = Angle which the force P makes with the horizontal.

Then by construction $OSCO$ is a right-angled triangle and from the laws of trigonometry the values of H and V can be determined in terms of the force P and the angle a, or

$$H = P \cos a \qquad (1)$$

and

$$V = P \sin a \qquad (2)$$

Problem 1—A force of 200 lb. makes an angle of 30 deg. with the horizontal. Find the horizontal and vertical components of the force.*

Solution—In Fig. 3, let OS represent the given force P = 200 lb. to scale; let angle SOX = 30 deg.

Construct the rectangle $ONSMO$ with OS as one diagonal. Then the line OM will represent the horizontal component H, and the line ON the vertical component. These lines can be measured and will give the numerical value of the components, or equations (1) and (2) can be applied and the components found. Thus, $H = P \cos a = 200 \times \cos 30° = 200 \times 0.866 = 173$ lb., and $V = P \sin a = 200 \times \sin 30° = 200 \times 0.5 = 100$ lb.

If the components of a given force are known the magnitude and direction of the force can be determined as follows: In Fig. 2, since $OSCO$ is a right-angled triangle,

$$P^2 = SC^2 + OC^2$$

(the square of the hypotenuse equals the sum of the squares of the other two sides), but $SC = OD = V$ and $OC = H$; therefore

$$P^2 = H^2 + V^2$$

or

$$P = \sqrt{H^2 + V^2} \qquad (3)$$

The tangent of the angle is

$$\tan a = \frac{SC}{OC} = \frac{V}{H} \qquad (4)$$

From the last equation the angle itself may be found with the aid of a table of natural trigonometric functions.

Problem 2—The horizontal component of a force is 30 lb. and the vertical component is 40 lb. Find the direction and magnitude of the force.

Solution—Lay off OD = 40 lb. and OC = 30 lb. to scale, as in Fig. 4.

Draw DS parallel to OC and CS parrallel to OD and draw the line OS which will represent the unknown force P. Then

$$P^2 = OD^2 + OC^2 = 40^2 + 30^2 = 1600 + 900 = 2500$$

Therefore,

$$P = \sqrt{2500} = 50 \text{ pounds}$$

$$\tan a = \frac{SC}{OC} = \frac{40}{30} = 1.333+$$

and the angle whose tangent is 1.333 is found to be 53 deg.

To aid in the problems that will follow later in the course, all components acting either to the right, or upward will be considered as positive forces (+), and all forces acting downward, or to the left will be considered as negative (—), as indicated in Fig. 5.

Forces which pass through a common point are called *"con-current forces,"* and those whose lines of action do not pass through a common point are called *"noncon-current forces."*

STUDY QUESTIONS

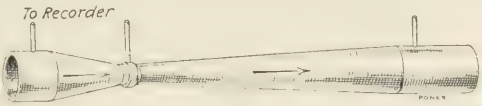
1. What is the broad term for the action of forces on bodies?
2. What is force; how does it manifest itself?
3. When steam is admitted to the cylinder of an engine, where does the pressure find its reaction?
4. What is the component of a force?
5. What is meant by the terms gravity and weight?

⁂

Venturi Meter

Old as it is, there are some who know the venturi meter by name better than by principle. They are inclined to think of it as a device with properties that are a bit mysterious, whereas it is really quite simple, when understood, and not at all difficult to understand, when analyzed.

The venturi meter is a modern application of a curious phenomenon known for many years. Where a jet of water or a stream is compelled by following pressure to hurry through a narrowing passage, its tendency to exert lateral pressure is reduced. It is possible with a well proportioned narrowing throat actually to cut away a pipe, and the moving jet will jump the gap and continue in the pipe to move against the pressure without escaping laterally. This meter consists of a short throat in a pipe, and is joined to it by conical lengths. These compel the water to travel gradually more rapidly, and the throat velocity is several times that in the pipe at each side of it. Pressure gages on the pipe and on the throat will show different pressures, that of the throat jet being the lesser. This pressure difference is recorded in terms of gallons passing.



VENTURI METER

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*Note—In the solution of problems in mechanics the student will find the work very much simplified if he will make a neat sketch showing the relative position and magnitude of all the forces involved, as well as their direction.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Mon Dew! The French Feather Association has refused to exhibit at the coming Panama Pacific Exposition. Here's another blow at our little show. How can we have an exhibition without a few French feathers? What's the matter, Messieur Jacques, are ze petite birds doing ze moult, or do you suffer ze pip because of your Oncle Sam's restrictions on those dear feathers from that gay Paree?

⁂

We are highly indignant that a suffragette should have smitten with an axe the rather speaking likeness of Miss Venus Rokeby, in the London Gallery. No gent would take an axe to a lady, and as we are led to believe that these suffering ladies want to be treated as real gents, this violent proceeding is ungentlemanly.

⁂

The British papers raised a bally rumpus when Cousin Thornton crossed the pond to assume charge of the Great Eastern Railway. And by jove, y'know, 'twas Lord Claud who chose the bounder! Now that Cousin Cooper, because of his good work at Keokuk, has been selected by Sir Ralph to help engineer the big Nile project— My word, old top, there'll be war among the engineering Johnnies at home, I'm thinkin', eh, what?

⁂

More honors for astronomic science! We ask a salute of 21 guns for Annie Jump Cannon, curator of astronomy at Harvard University. Annie has "distinguished the type to which a star spectrum belongs." Easy to see now why the London Society has bestowed honorary membership upon her. We would jump at this ourself if we could. In lieu of which we are glad to let Annie Jump.

⁂

To the printers' art we owe a great debt. Technical and trade papers, especially, owe their beauty, their typographical culture and their clarity to this art. And no one man has done so much to develop and beautify it as has Theodore L. De Vinne, who died recently. All honor to his memory!

⁂

The germers are at it again. This time it's the humble sandwich, which should not be eaten on grounds of dietetics or of economy. Can't somebody discover a harmful germ in the lubricating oil or a boll weevil in the cotton waste? Our vocation is running at slow speed with the fashionable trend.

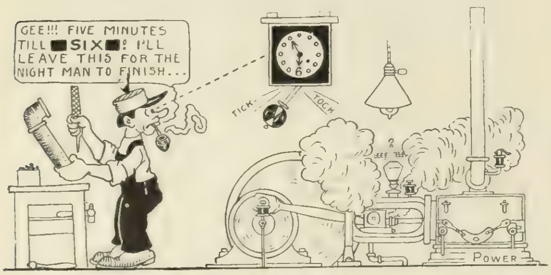
⁂

Another startling thing, according to the papers, is that "marriage is a science." Poof! It's an exact science. We've known this for 25 years. If some of you young or soured single engineers are skeptical, try it. Trying's believing.

⁂

"Imperator" Is a New Ship—Headline.

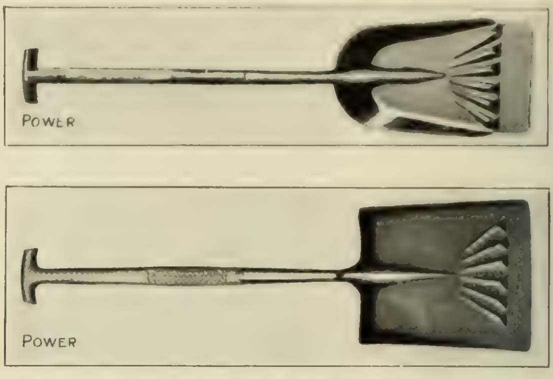
Before her recent extensive alterations she was said to be "tender" (likely to roll). It's pretty tough for a new ship to be so tender that it takes a roll of 5,000,000 marks to keep her from rolling. Another alteration has provided better accommodations for the firemen. That's real human in a world where firemen are commonly considered—well, just firemen, until they jump overboard. Then they're crazy.


GEE!!! FIVE MINUTES TILL SIX! I'LL LEAVE THIS FOR THE NIGHT MAN TO FINISH...
TICK
TOCK
POWER

Looks Like the Night Man Was Going to Have a "Pipe"

"Fire King" Sprinkler Shovels

These shovels have been designed chiefly for boiler firing, to insure better results with cheap grades of fuel, by assisting the fireman in sprinkling it thinly over the fire. Unless a fireman is expert, the fuel leaves the shovel in a thick mass, requiring several shovelfuls to cover the surface of the fire. The result is that the fire is covered with a thick layer of green fuel, which cools the furnace, and retards the admission of air at a time when the maximum quantity is required for the combustion of the liberated gases.



Two Patterns of "Fire King" Sprinkler Shovel

The sprinkler shovel is made with six raised ribs pressed from the steel plate of which the shovel is made. The ribs are made at an angle from the center toward the outsides and front edges of the shovel, as shown in the accompanying illustration. The idea is that as the fuel leaves the shovel the ribs give it the spreading or scattering effect, desirable with hand firing.

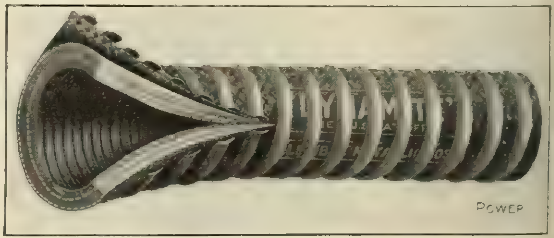
This shovel is made by Clarence A. Fell, Dronfield, near Sheffield, England, who also holds the United States patent.

⁂

"Dynamite" Flexible Metallic Steam Hose

If a steam hose is not properly made, the inner tube will soon buckle and become broken, and, although sections of the hose may be fit for use, the defective parts condemn the whole.

A design of hose which appears to be so constructed for long service is illustrated herewith. It is made with an inner protection of spiral wire embedded in rubber, to prevent collapsing. Then comes a ply of heavy duck, shown by the white dotted line. Next is the tube proper,



Cut Section Shows How the Hose Is Constructed then a second ply of heavy duck, and a rubber cover. Over this is placed an armor-braided covering of nonrustable, annealed steel wire. This covering will withstand a working pressure of over 1000 lb. per sq.in., and takes care of all strains due to internal pressure.

The braided covering is spirally wound with half-round nonrustable steel wire, which takes care of any external wear to which the hose may be subjected. The spirals do not crowd together and if they are cut they will not loosen.

This hose, made by the Malconroy Co., 722 Arch St. Philadelphia, Penn., will not kink or collapse. It is specially adapted for boiler testing, blowing tubes, and where high steam or air pressure is to be used.

The Care of Wire Rope*

SYNOPSIS—A kinked rope may be straightened but the rope will be weakened. When a running rope has a socket attached to the end, water may collect and cause corrosion; the remedy. Rapid deterioration of ropes is often due to corrosion that could have been prevented by the use of a lubricant which would have reached and protected the inside wires.

⁂

Experience has taught that there are four leading causes for the destruction of wire rope, namely, abrasion, overstrain, undue bending and corrosion. In time, one or more of these causes will so weaken a rope that it can no longer support the load for which it was designed. When it fails, from any of the above mentioned reasons, the cause can usually be determined from the appearance of the rope. If, for example, the wires wear thin in a short time, the rope has been subject to abrasion; if the wires are but little worn and broken off squarely, usually sticking out all over the rope, it has suffered from either severe bending stress or overstrain; and if the wires are rusty and pitted, corrosion is to blame.

Causes of Abrasion

Abrasion in a wire rope is frequently the result of one of the following causes: (1) Faulty grooves in wheels that are roughly worn or too small for the rope.

(2) Dragging of the rope upon the ground or over some fixed obstruction.

(3) Using a rope under conditions for which none but the toughest steel (plough or improved plough) is adapted, and failing to select ropes of such grades.

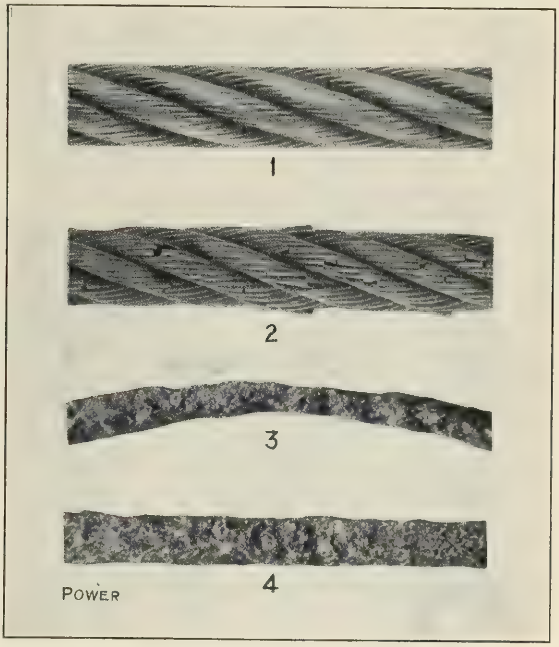
Another cause for sudden breaking may be excessive abrasion at some point. This may occur to ropes running on slopes over heavy knuckle sheaves. After the train has come to a rest, if the sheave keeps on spinning, it tends to wear the portion of the rope resting upon it, and that part will slowly wear and become weak.

Causes of Broken and Corroded Wires

Badly broken wires, showing excessive bending, indicate that the wheels are too small or too numerous. They should be rearranged or a more flexible rope used.

Rope badly corroded shows the lack of proper lubrication. Local corrosion sometimes causes failure. If, in passing through a place in which water is dripping from the roof, a rope is allowed to lie still for a considerable length of time, the part exposed to the drippings will rust faster than the rest.

In addition to the destructive causes mentioned above, ropes sometimes suddenly tear apart. Such cases are invariably the result of accidents to machinery or appliances, which bring upon the rope a load far beyond its capacity, or they are due to a serious weakening of the rope at the point of rupture, caused by some local abuses. Such abuse should by all means be avoided. A new rope made from the materials and with the care that distinguishes "A-1" quality, is sent from the factory as nearly perfect as a mechanical product can be and the purchaser should protect the rope from those injuries which may with very little care be prevented.



Rope in Service

1—Wire Rope Used under Proper Conditions, Shows Normal Wear. 2—Wire Rope that Has Been Subjected to Short Bends, Causing Broken Wires. 3 and 4—Enlarged Views of Pieces of Wire Taken from Badly Rusted Rope.

One of the most common of these injuries is the damage arising from "kinking." If for any reason the rope is allowed to form a loop, and this loop is drawn taut, a kink will result. Though the kink may be straightened out, it leaves a permanently damaged and weakened spot and so should always be avoided.

When a running rope has a socket attached to the end, constant vibration tends to weaken the wires, and this weakness is increased if water collects directly over the end of the socket. It is, therefore, advisable every three to six months to cut off a piece from the end of the rope and reattach the socket.

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*From the January issue of the "Employees Magazine," published by the Lehigh Valley Coal Co., from material furnished by the John A. Roebling's Sons Co.

Besides the causes mentioned, the effects of which are usually revealed by inspection, temporary overloads producing excessive stresses are sometimes applied, and by straining the wires beyond their elastic limit these tend to shorten the life of wire rope. Such excessive stresses are more apt to occur where a rope is slack, or is attached to a short length of slack chain, and the power to lift or haul a load is suddenly applied, with the result that, instead of the rope gradually adapting itself to the required pull, it is subjected to the jerk arising from the full inertia of the load. Lifting tests made on wire ropes, attached to chains having from 2½ in. to 12 in. of slack, show that when loads are applied suddenly, the stresses are from one to four times as great as those sustained when the same loads are gradually applied. Therefore, care should be taken to avoid, as far as possible, such pulls and jerks.

Wire-Rope Lubrication

When a complaint is made that a wire rope has not given satisfactory service, the first questions asked by the manufacturer are: "How was the rope lubricated?" "What is the condition of the inside wires?" These questions arise because the experienced wire-rope maker fully appreciates that a wire rope is a complex piece of machinery and knows that the importance of proper lubrication is too often overlooked. Sometimes a wire rope is covered with a compound too thick to penetrate beyond the outside wires. The effect of this is to leave the inside strands without protection against water and moisture.

Examinations of ropes that have fallen short of the period of good service, frequently show the outside wires to be in apparently good condition, while the areas of the inside wires have been materially reduced and the whole rope weakened. This is due to corrosion that could have been prevented by the use of a lubricant which would have reached and protected the inside wires.

A lubricant or preservative should not only penetrate to the hemp center, in order to saturate it and prevent absorption of water, but it should also coat thoroughly the inside wires of each strand. This cannot be expected from thick, heavy and sticky compounds or the greases frequently used for the lubrication of wire ropes, which were made primarily for some other and quite different purpose.

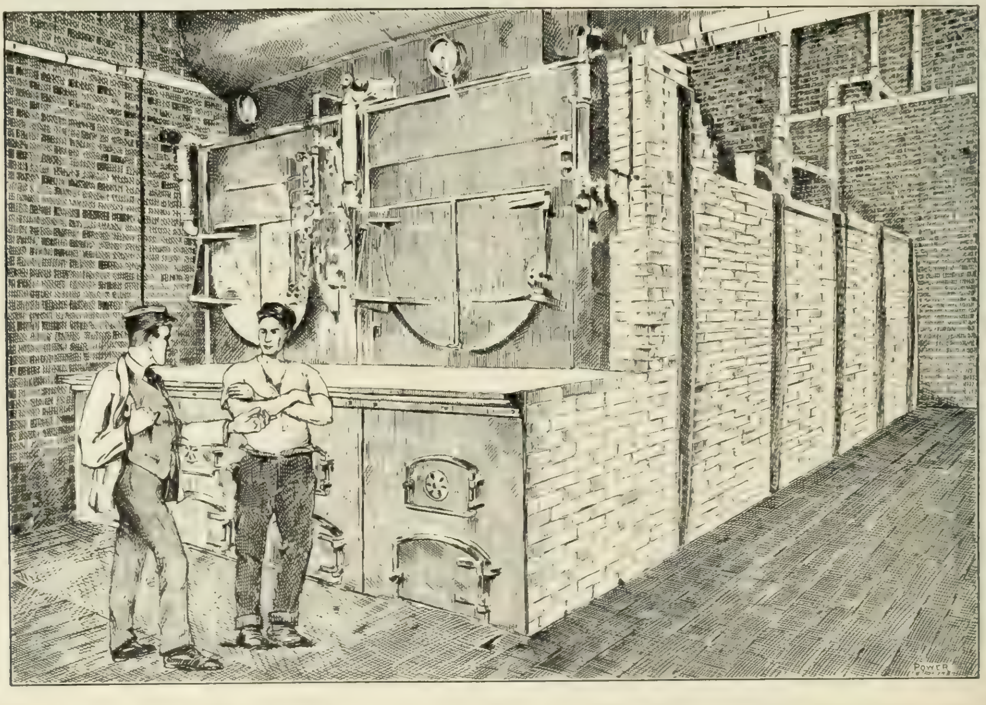
⁂

The Dutch-Oven Furnace

By J. E. Fulweiler

"What gave you the idea of building a box for a furnace in front of these boilers?" asked the fireman of the engineer, who had dropped in to see how matters were going on in the boiler room.

"It started this way," replied the engineer, as he tapped the bowl of his favorite pipe on the heel of his shoe. "The boss had been after me for some time to stop making so much smoke, as the town authorities



"What's the Joke?" Asked the Incredulous Fireman. "You Move the Fire away from the Boiler and Lose a Lot of Heat and Then Say You Have Improved Things."

were after him hard. I couldn't see much harm in smoke, but just to please him I tried several schemes to prevent it, and did cut it down considerably. But when the peak load came on, the smoke would pour out of the top of the stack as usual.

"About that time I decided to go to night school and see if I could learn anything from the dudes over there. The chemical part was interesting, and I began trying to solve the smoke problem on my own hook. I got busy studying, and gradually got what I was after."

"Well, you moved the fire away from the boiler tubes out in this dutch-oven thing, that's sure," replied Sam with a dissatisfied grunt.

"That is right, but have you noticed that you are not shoveling as much coal into the furnace as you did before the change, and that there is hardly any smoke?"

"No," said Sam, "I have been so busy getting used to the thing, but I guess you are right about the coal and smoke, but we haven't had much of a load on this morning."

"As a matter of fact," said the engineer, "we have both machines working as hard as they can, and the test run yesterday showed a big increase in economy."

"What's the joke?" asked the incredulous fireman, "you move the fire away and lose a lot of heat and then say you have improved things."

"That's right," answered the engineer, "the bituminous coal we are using is composed of moisture, carbon, ash and what are called hydrocarbons or volatile matter. This volatile matter is what you see burning with the long, red flame. The carbon itself burns with a short, colorless flame. The volatile is driven off as a gas from the fresh coal and burns first, then the coal becomes coke and burns with a colorless flame."

"Do you mean to say that the only difference between coal and coke is that coal contains gas and that coke does not? How do you explain it, then, that coal is so much heavier than coke; doesn't gas weigh less than nothing?"

"The coal we are using has, by weight, 5 per cent. moisture, 27 per cent. volatile carbons, 58 per cent. fixed carbons and 10 per cent. of ash. Coke contains about 87 per cent. fixed carbon, 12 per cent. ash and 1 per cent. sulphur. As regards gas not weighing anything, you are probably comparing it to air, which you assume has no weight.

"You would not say that cork has no weight, yet it will float to the surface if submerged in water, because it has less weight than, or one-fourth the specific gravity of water. Gas moves up in air for the same reason, because it is lighter than air. If you take a large bottle and pump the air out, and weigh the bottle on a sensitive scale and then weigh it when filled with gas and then filled with air, you would find that the gas and air had weight. In fact, 13.1 cu.ft. of air at 60 deg. F. and 14.7 lb. abs. pressure weighs 1 lb. As the temperature is increased, if the air is not inclosed, it will expand and, therefore, weigh less per cubic foot. That is the reason why hot air will rush up the stack into the cooler air

"Volatile gases are consumed by the chemical action of the oxygen in the air while at high temperatures, but are not affected in the same way when the temperatures are reduced. Carbon and hydrogen, in various proportions, are the constituents of the volatiles, and they combine with oxygen to form water vapor, carbon monoxide and lampblack, or carbon dioxide, depending on the proportion and temperature of the available oxygen.

"The two most common causes for poor combustion are insufficient available oxygen and premature cooling of the flames. You may understand about the necessity of a proper supply of air, but you evidently haven't noticed the effect of cooling the flames prematurely. The trouble is that if the temperature of the combustion space is low the chemical action is retarded, and, instead of the carbon and oxygen uniting to form the products of combustion, as carbon dioxide, they will partly go to form carbon dioxide and carbon monoxide, and part will separate as carbon or lampblack.

"You cannot see the carbon monoxide going to waste, but fortunately you can see the carbon which shows as smoke."

"Then," remarked Sam with evident surprise, "smoke is part of the coal going to waste."

"Yes, you are right, and when you see smoke you may be sure that some carbon monoxide is going to waste."

"But," Sam inquired, "I don't quite get you on that last. What good is that stuff?"

"That is the important part," answered the engineer. "The loss of the carbon monoxide is where the real waste occurs. If the temperature surrounding the flame is kept high and the proper supply of air is given, this carbon monoxide would have burned to carbon dioxide, which would have produced additional heat in the furnace. It is for that reason that we moved the grate out into dutch ovens or boxes as you call them, so that the radiant heat will be reflected down from the arch instead of being absorbed by the tubes overhead, thus keeping the temperature of the combustion chamber high and giving those long-flamed gases a chance to be consumed before coming in contact with the comparatively cool tubes. The carbon that is left in the coke burns much in the same manner as coal, partly to carbon monoxide and partly to carbon dioxide. The carbon monoxide, however, burns to carbon dioxide when the proper supply of air comes into contact with it.

"With coke or anthracite coal the combustion is practically complete to within a few inches from the surface of the fire, so the extension furnace is not quite so essential."

*

Power from the Sun

In commenting upon a remark by the *Scientific American,* to the effect that "The capture of the sun's heat has been attempted, but on a very small scale, and by an ineffective method," Frank Shuman, of Tacony, Philadelphia, whose experiments in the direction of absorbing the heat from the sun in low-pressure boilers have been referred to several times in POWER, says: "Our sun-power plant of 1911 turned 43 per cent. of the heat of the sun which reaches the earth's surface into steam, and our present plant, tested during the end of August, 1913, turned 57 per cent. into steam, an improvement of 14 per cent. in two years. This record should encourage us in thinking that during the next ten years we shall be able to reach the 75 per cent. efficiency of the best modern steam boiler, and thereafter possibly surpass it." [The best modern steam boiler now does over 80 per cent.—ED.].

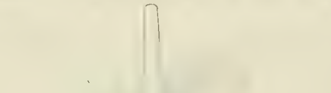
The sun's heat absorbers at Cairo occupy less than an acre of space, and develop 50 b.hp. throughout a 10-hr. day. The area of sunlight intercepted is only 13,269 sq ft., or less than one third of an acre, but it is necessary to place the heat absorber units sufficiently far apart so that they will not shade each other in the forenoon and late afternoon. On the above basis it would be necessary to cover 20,250 square miles of ground in the Sahara Desert, with the sun heat absorbing units spaced as wide apart as they are now to give perpetually the 270,000,000 hp. required to equal that which would be produced by all the fuel mined in 1909. The area of 20,250 square miles is practically equal to a square of 143 miles on the side, which is only a very small part of the Desert of Sahara, from which Mr. Shuman argues that the sun power can take care of the human race for all time.

In reply to the question, "How much will it cost to do this?" he gives the startling figure of $98,500,000,000. A well informed and independent engineer estimates the cost of construction and erecting of the 50-hp. sun-heat absorbers referred to above at $7600. The above figure is obtained by proportion from this result. "Having planted the desert with sun-heat absorbers at a cost of ninety-eight odd billion dollars," says Mr. Shuman, "we have a plant that is worth as much as all the coal and oil fields in the world, because it can perpetually give as much heat and power as all of the coal fields and oil fields of the world put together, if mined at the 1909 rate, and they are certainly worth very much more than ninety-eight odd billion dollars."

⁂

Will Oil Can

The Will oil can, illustrated herewith, is made of pressed steel, with the exception of the shaft connecting the plunger or piston with the button, which is operated by the thumb. The bottom of the can is of stiff steel.



New Design of Oil Can

This can, made by the Will Manufacturing Co., 1742 Monadnock Block, Chicago, Ill., is operated by pressing the button in the center of the bottom, as with the flexible-bottom or air-cushion can.

The button is connected with a piston, packed with leather, by means of a shaft incased in a tube that fits into an oil-tight cup at the top, which effectually prevents oil from running out the spout.

The piston or plunger *A* is forced into the cylinder *B*, which is a part of the spout on the inside of the can, and forces the oil out. Thick oil can be readily fed through the spout as the tendency to clog is eliminated.

Recent Court Decisions

Digested by A. L. H. STREET

Municipal Regulation of Electric Power Rates—The law enacted by the Missouri legislature in 1913, vesting power in the Public Service Commission to fix rates for service afforded by public utilities, was lately held by the Missouri Supreme Court to have nullified an ordinance of the city of St. Louis which prescribed a maximum rate for electric current. In reaching this decision, in the case of the Union Electric Light & Power Co. vs. the City of St. Louis, the Supreme Court touched upon the regulatory powers of cities. The ordinance in question prescribed a maximum rate of 9½ per kw.-hr. for electric current, and declared that all electric companies should be bound by certain "regulations," including a requirement that meters be furnished free of cost and a prohibition against contracts binding consumers not to use other means than electricity for light or power, or to use current for a longer period than one month, or to use a certain quantity of current, etc.

The attorneys representing the city conceded that it was beyond the power of the city to establish a maximum rate for electric service, as a "regulatory" measure, but insisted that the other provisions just mentioned were valid as tending to protect the public against any "improper or harmful manner in which the service might have been rendered," and, hence, were within the proper exercise of the police power of the city. Meeting this contention, Justice Bond, speaking for the Supreme Court, said: "We cannot assent to that view. An analysis of the various regulations contained in the ordinance discloses that each and all of them relate to the question of the price at which the plaintiff might sell its electric current, and do not touch even remotely upon the health, morals, and welfare of the public, or the conservation of its property, or upon any subject falling within the just protection of the police power of the city. Take for instance the requirement of free meters; that was evidently designed to bring within the maximum rate all expense attendant upon securing the service of electricity. In other words it was the intention of the framers of the ordinance that all meter cost should be absorbed in the maximum rate of charge. That regulation bore no possible relation to any matter lying within the just domain of the police power.

"The same may be said of the regulation as to lamp renewals without cost to the consumer. The other regulations related to restrictions upon the power of the plaintiff to make contracts with its consumers for the purpose of securing the payments of its charges; such regulations are not only outside the police power, but they are in contravention of the Constitution, which guarantees to the citizens the right of freedom of contract as to any lawful subject matter. * * * As the city had no power under its charter to fix any rate of charge for the use of electricity, it necessarily was without charter power to affect the price at which it was sold to the public by regulatory provisions contrived solely to that end, for that would be pro tanto a fixing of the price, and this, as has been seen, it had no charter power to do."

The court found that a law which expressly conferred power on the city of St. Louis to fix rates for electric current was repealed by the Public Service Commission law above mentioned.

Power Privileges in Deeds—The permanent nature of provision in deeds for power privileges as an appurtenance to the land conveyed was involved in the case of Miller vs. Clary (103 "Northeastern Reporter," 1114), which was recently before the New York Court of Appeals. Many years ago, a flour-milling company at Seneca Falls owned a tract of land upon which its mill was situated. It subdivided part of the tract into lots and sold them under deeds which bound the company to furnish "sufficient power (subject to the elements) from a wheel in the Old Stone Mills to turn a shaft and propel machinery in the basement of any building to be erected on the premises hereby conveyed, not requiring more than 15 hp.," etc. The milling company bound itself to keep the wheel in good condition and to maintain the shaft to the line of the lots conveyed. The power was furnished according to the deeds for several years, but later its transmission was suspended and the appliances for conveying it were destroyed by the elements or otherwise. All the land involved passed into the hands of purchasers and the question recently arose as to what were the rights of the present owners of the lots against the owner of the old mill property on which an electric-power plant is now in operation, in which plant there are waterwheels. On these facts, the Court of Appeals holds that the grant of "sufficient power . . . to turn a shaft," etc., was permanent in the sense that it passed to successive purchasers of the lots; not being personal to the original purchasers, and, hence, they are entitled to have power supplied to them according to the deed. But the court holds that the clause requiring the grantor to construct and maintain the shaft was personal to him, and was not binding upon his successors in ownership. Accordingly the present owners of the lots must bear the expense of reconstructing and maintaining the shaft.

Right to Use water for Mill Pond—An owner of land adjacent to a mill pond, under a deed giving title to one-half the bed of the stream, is entitled to a reasonable use of the water in the mill pond, for use in generating power, if the rights of the mill-dam owner are not thereby impaired to a material extent. (Georgia Supreme Court, Rome Ry. & Light Co. vs. Loeb, 80 "Southeastern Reporter," 785.)

*

An Unusual Boiler House

Built as part of Boston's new nine-million-dollar port development, the boiler house on the Commonwealth fish pier has some unusual features, consisting as it does of three distinct structures within the four walls. For various reasons, including a delay in the delivery of structural steel, the reinforced-concrete walls of this building were put up and completed by the Aberthaw Construction Co., Boston, before the steel was on the ground. The structural members have been erected inside the walls to carry the floors and the huge coal pocket, and are independent completely of the walls themselves. The third structure, which also is of reinforced concrete, is the big chimney located in the building near one corner.

The outside dimensions of the concrete structure are 56 ft. 6 in. by 70 ft., with a height above the ground floor of 79 ft. This structure is virtually an enormous concrete box without internal bracing of any sort. It is not tied together by the structural members, as would have been the case under ordinary conditions of erection. It is constructed wholly of concrete with steel reinforcing bars, there being no structural steel members embedded in the concrete, either for wall columns or wall beams. All of these are of reinforced concrete only, giving the outside of the building something of a lattice-work effect on a huge scale—an effect which is enhanced by the almost total absence of windows and other openings.

BOOKS RECEIVED

THE ENGINEERING INDEX ANNUAL. By the "Engineering Magazine," New York. Cloth; 508 pages, 6½x9½ in. Price, $2.

HOW TO BUILD UP FURNACE EFFICIENCY. By Jos. W. Hays, Rogers Park, Chicago, Ill. 7th edition; paper; 126 pages, 5x7¼ in.; illustrated. Price, $1.

INDUSTRIAL CHEMISTRY. By Henry K. Benson. The Macmillan Co., New York. Cloth; 431 pages, 5x7½ in.; illustrated; tables.

THE EFFICIENT MAN. By Thomas D. West. The Gardner Printing Co., Cleveland, Ohio. 330 pages, 5x7½ in.; illustrated. Price, $1.50.

NEW PUBLICATIONS

THE ENGINEERING INDEX ANNUAL, 1913; 508 pages; 6x9; cloth; The Engineering Magazine Co., New York; price, $2.

The volume of engineering literature produced is such that it is a serious task, even with the specialist, to keep up with the contributions to his particular field of activity. Such an index as that published monthly by the "Engineering Magazine" serves a very useful purpose to the intelligent user, and when these indexes are aggregated into yearly volumes one has an indication of and direction to everything of moment which has appeared upon any engineering subject in the period of time covered by the index, in about 250 publications, representing 17 nations and colonies, and six languages. The latest volume brings the investigator down to the December, 1913, issue of the Engineering Index in the "Engineering Magazine, covering the serial literature of engineering up to October, 1913.

*

International Engineering Congress, 1915

Rapid progress is being made in working out the final program of papers for the International Engineering Congress to be held in San Francisco in 1915.

The first volume of the publication of the Congress will consist of a series of articles descriptive of the various technical features of the design and construction of the Panama Canal. This will include 22 topics each of which will be treated by an engineer who has been responsible for the design and construction described. The introductory chapter as well as the topic of "Dry Excavation for the Panama Canal" will be handled by Colonel Goethals himself.

This volume will constitute practically an official technical record of the gigantic engineering feat which is just nearing completion and will be of interest, not only to engineers but to laymen.

No similar volume has as yet been prepared upon the canal, nor is it probable that any such will be in the future. The advantage is being taken of the congress to draw together under one cover in this way, the statements of the men who have been responsible for the work.

The program of papers for the various sections of the congress is practically completed and notices of them will be published in the near future. Subscriptions to the congress are being received daily and on Mar. 1 the number of enrollment was slightly in excess of 1200, of which over 200 are from foreign countries and about 1000 from the United States. Subscription blanks have been mailed through the various national societies to many thousands of engineers in this country and through the foreign societies to foreign engineers. The response already received is very encouraging, but it is trusted that all engineers interested in the success of the congress will not fail to send in their subscriptions as early as possible. Delay in so doing renders the task of the committee of management more difficult, and makes it impossible to form any just estimate of the receipts which may be expected and the number of copies of the volumes which have to be published. E. J. Dupuy, Foxcroft Building, San Francisco, Calif., is the executive secretary.

OBITUARY

GEORGE WESTINGHOUSE

George Westinghouse, the well known inventor and engineer, died of heart disease at his New York City residence on Mar. 12. His health had been failing for some time, and during the past year or two, he had withdrawn from active participation in many of the industries with which he had long been associated.

Born at Central Bridge, N. Y., Oct. 6, 1846, he attended the public schools of that town, spending much of his leisure time in his father's machine shop. This early practical experience proved of inestimable value in later life when working out the details of many of his inventions. He later moved to Schenectady where his father engaged in the manufacture of agricultural machinery.

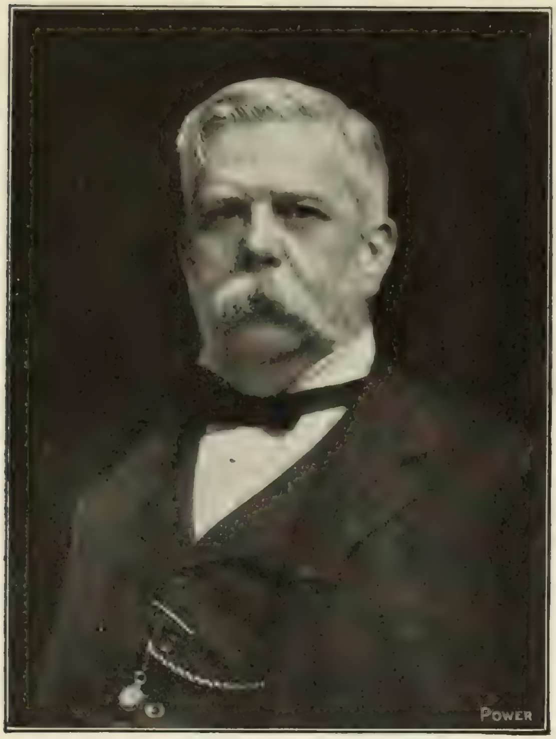
At the age of 17 he enlisted for the Civil War in the New York National Guard, and later entered the navy as third assistant engineer, where he saw service with the Potomac flotilla. Returning at the close of the war, young Westinghouse entered Union College, where he remained until the end of his sophomore year. He abandoned classical studies, however, for active life to find a wider scope for his inventive genius.

One of his first inventions was a rerailing frog. The idea of this was suggested one day upon returning from a trip to Albany when the train was delayed by the derailing of a freight train ahead. He returned home, made some frogs, and with two other men who furnished $5000, started his first factory to manufacture the invention. He held the patent in his own name, however. When the device was on the market the partners demanded that he make over the patents to them. Westinghouse refused, and the partners seized the business, which without the young inventor soon failed. He then went to Pittsburgh, where he became a salesman for

Alexander & Woods, a steel-casting company. This firm took up the rerailing frog and made it a success.

About this time on a trip to Troy, he witnessed a bad train wreck, due primarily to failure of the handbrakes to operate in time. The idea occurred to him that a brake under the control of the engineer could have prevented the accident. He thereupon set about to devise such a brake, evolving first an automatic brake attached to the couplers, but this was unsuccessful, and was followed by a steam operated brake, which also proved unsatisfactory. Compressed air was next tried, and proved successful, the first patent being obtained April, 1869, and the Westinghouse Air Brake Co. was founded the following July. From this time, many changes and important improvements were made in the air brake, and Mr. Westinghouse spent seven years, from 1871 to 1882, in Europe introducing his invention and adapting it to meet European railroad conditions.

About 1880 Mr. Westinghouse became interested in the operation of railway signals and switches by compressed air, and soon after developed and patented the system now manufactured by the Union Switch & Signal Co.



GEORGE WESTINGHOUSE

Six years later the Westinghouse Electric Co. was formed for the manufacture of lamps and electric-lighting apparatus. This grew into the Westinghouse Electric & Manufacturing Co., which now has extensive works at East Pittsburgh and employs over 22,000 people. Mr. Westinghouse was president until the panic of 1907, when the company became financially involved and in the reorganization new interests were put in control.

In 1892 he procured the contract for the electrical equipment of the World's Fair at Chicago, and a year later the contract for the large generators at Niagara Falls, both of which mark epochs in the progress of the electrical industry. He was one of the early champions of alternating-current transmission, and it was due largely to his persistent efforts in the face of strong opposition, that this system was introduced and developed in this country at the time.

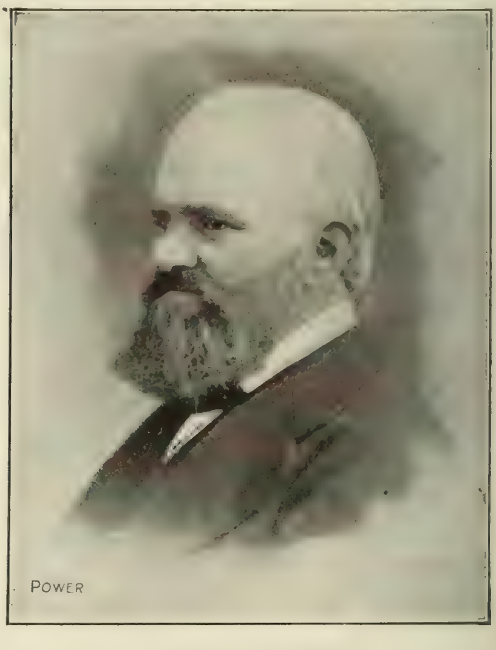
Among the companies with which Mr. Westinghouse was identified are the Westinghouse Air Brake Co., the Westinghouse Machine Co., Nernst Lamp Co., the Union Switch & Signal Co., Société Anonyme Westinghouse, of Paris, the Cooper-Hewitt Electric Co., Pittsburgh Meter Co., Societe Italiana Westinghouse, Italy, the Westinghouse Brake Co., Ltd., of London, the Westinghouse Cooper-Hewitt Co., of London, and the Westinghouse Metal Filament Lamp Co., of London. He was also chairman of the Board of Directors of the Westinghouse Electric Co., Ltd., London, and director of the Westinghouse Electric & Manufacturing Co., the Traction & Power Security Co., and the Westinghouse Metallfaden Gluhlampenfabrik, Vienna. These companies employ over 50,000 men, and have a total capitalization of $200,000,000.

Among the honors conferred upon Mr. Westinghouse in acknowledgement of his many achievements were the degree of doctor of philosophy by Union College, the French Legion of Honor, the Royal Italian Order of the Crown, and the Order of Leopold of Belgium. He was the recipient of the John Fritz medal, also the Grashof medal presented by the German engineers; an honorary member and past-president of the American Society of Mechanical Engineers, and an honorary member of the American Society.

A widow and one son survive him.

JOHN F. SHEARMAN

Older readers of "Power" will recall the contributions of Peter Van Brock. Although this was understood to be a nom de plume, he would give no other particulars regarding himself, and it is only with his decease, which occurred at Hillsdale, N. Y., on the 6th of this month, that his identity became revealed. His name was John F. Shearman, and he was born in London on July 1, 1828, coming to America in 1844. His father was John H. Shearman, a noted surgeon, and the son studied medicine, but gave it up for the study and practice of mechanical engineering. He was the inventor of numerous mechanical devices, also of a gunpowder which he sent to the James River in 1865 to demonstrate. It was at about this time that he began to write for the mechanical papers under the nom de plume of Peter Van Brock, and only recently have his contributions ceased to appear.



JOHN F. SHEARMAN
(PETER VAN BROCK)

Thomas G. Shearman, deceased, of the law firm of Shearman & Sterling, in New York City, and James A. Shearman, an artist, of Switzerland, are brothers. In 1905 John F. Shearman moved to Jefferson, Iowa, but returned in 1912 to end his days at Hillsdale, N. Y.

JAMES HONOR

James Honor, chief engineer at the power plant of the Altoona & Logan Valley Electric Ry., Altoona, Penn., is dead. Mr. Honor had been a resident of Altoona for the last ten years. He was born in Schuylkill County on Apr. 10, 1866, and was educated in the schools of that county, and soon afterward entered upon an apprenticeship in a machine shop. He entered the employ of the Logan Valley Ry. in 1904.

POWER

Vol. 39 NEW YORK, MARCH 31, 1914 No. 13

Candid Chats

The Fireman's Complaint

YOU KNOW *that many firemen in office and public buildings, factories, etc., wonder why they have to work so hard nights, Saturday afternoons, Sundays and holidays during the winter. The power load is light and the temperature outside is not lower than ordinary, yet the work is much harder than it seems it ought to be, considering the light power load. The fireman complains to you and if you cannot satisfactorily explain the reasons for this seemingly large amount of extra work he gets real peeved. The next time that he demands that you shut off all live steam even though there is a vacuum in the system, hand him this article.*

* * *

Any building requires a given number of heat units to maintain a comfortable temperature in the rooms with a given temperature of the atmosphere. Assume that a particular building requires about 7,800,000 B.t.u. to be supplied every hour to keep the rooms comfortably warm, when the temperature of the atmosphere is such and such.

The engine (used for the day load) is 200-hp. noncondensing, and is run at about rated capacity. The steam pressure at the throttle is 150 lb. and the engine uses 35 lb. per hp.-hr. and exhausts into the heating system at atmospheric pressure.

Steam at 150-lb. gage (165 lb. absolute) contains 1195 B.t.u. per lb. So there will be supplied to the engine every hour

$$200 \times 35 \times 1195 = 8,365,000 \text{ B.t.u.}$$

One horsepower-hour equals

$$33,000 \times 60 = 1,980,000 \text{ ft.-lb}$$

And one heat unit equals 778 ft. lb. So 1 hp.-hr. $= \frac{1,980,000}{778} = 2545$ B.t.u.

As the engine develops 200 hp. it will convert into work each hour $2545 \times 200 = 509,000$ B.t.u

But 8,365,000 B.t.u. is supplied to it each hour, so the balance, or

$$8,365,000 - 509,000 = 7,856,000 \text{ B.t.u.}$$

will pass into the heating system. If this heat did not pass on it would remain in the engine and melt it.

As we need only 7,800,000 B.t.u. to keep the rooms warm we do not need any live steam. When the fireman gets on the night shift he expects easier work, and when he does not have it, he complains about the amount of live steam "on."

Night comes, the temperature drops and the load decreases from 200 hp. to say 20 hp., or say from 130 to 15 kw., but the building must be heated just the same. For the night load a small engine is used and we will assume this engine to use 35 lb. of steam per hp.-hr., the same as the large one.

Then there is supplied to this engine

$$20 \times 35 \times 1195 \doteq 836,500 \text{ B.t.u. per hr.}$$

The amount of heat converted into work is

$$2545 \times 20 = 50,900 \text{ B.t.u. per hr.}$$

The difference or

$$836,500 - 50,900 = 785,600 \text{ B.t.u. per hr.}$$

goes to the heating system.

We need to supply 7,800,000 B.t.u. per hr. to keep the rooms warm, so there is a shortage of 7,800,000 − 786,310 = 7,013,690 B.t.u. per hr. which must be supplied from the boilers. The heat must be furnished by the coal, and the fireman must shovel nearly as much at night or when the load is light as when the load is heavy and the weather just as cold. Of course, you do not make him do so; the weather does, and he should register his complaint with the weather man.

But, if live steam is on and is blowing to the atmosphere through the back-pressure valve, the fireman's complaint is justified.

Donaldsonville, La., Electric-Light and Water-Works Plant

By E. M. Ivens

SYNOPSIS—Steam-driven units are displaced by two oil engines. No comparison of operating costs is made in the performance of the two types of power generators, but the author believes that a new steam plant would have been more economical, and would have given better service than oil engines, due to operating conditions.

⁂

In December, 1912, the steam-actuated electric-light and water-works plant of Donaldsonville, La., fell before the many and repeated attacks of the oil engine, and contracts were formally entered into for the new machinery. The plant is municipally owned and operated, and after the many delays and controversies characteristic of such a decided change in practice, the old plant was shut down and the new one placed in successful operation the latter part of August, 1913.

In Fig. 1 is shown an exterior view of the present plant; Fig. 2 is a floor plan, showing the arrangement of the various units.

Engines

The prime movers consist of two 14x21-in., three-cylinder, 170-hp. oil engines, each directly connected to a 125-kv.-a., 2300-volt, three-phase, 60-cycle alternator. The exciter of each unit is belt driven from a pulley mounted on the engine crankshaft between the engine flywheel and the rotor of the generator. The shaft is extended beyond the crank case on the other side of the engine to receive a pulley for driving an air compressor.

Fig. 1. Donaldsonville, La., Electric Light and Water-Works Plant

One engine-generator set is sufficient to carry the commercial and street-lighting load, together with the general service motor-driven centrifugal pump. To operate the motor-driven fire pumps, it is necessary to run both engines. Fig. 3 shows one of the main units and both air compressors.

Air Compressors

For each engine there is a belted three-stage straight-line air compressor, size 8x4 and 2⅜x5 in. One is placed between the two engines with its belt wheel so located that it may be belt driven by either engine. The other

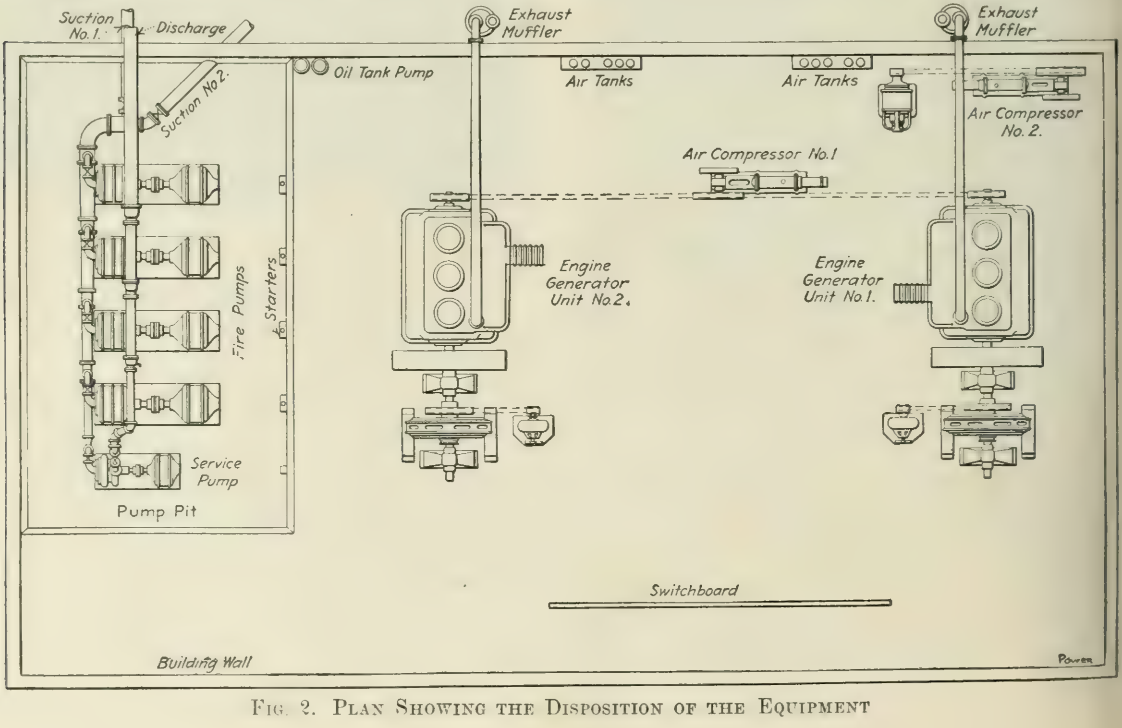


Fig. 2. Plan Showing the Disposition of the Equipment

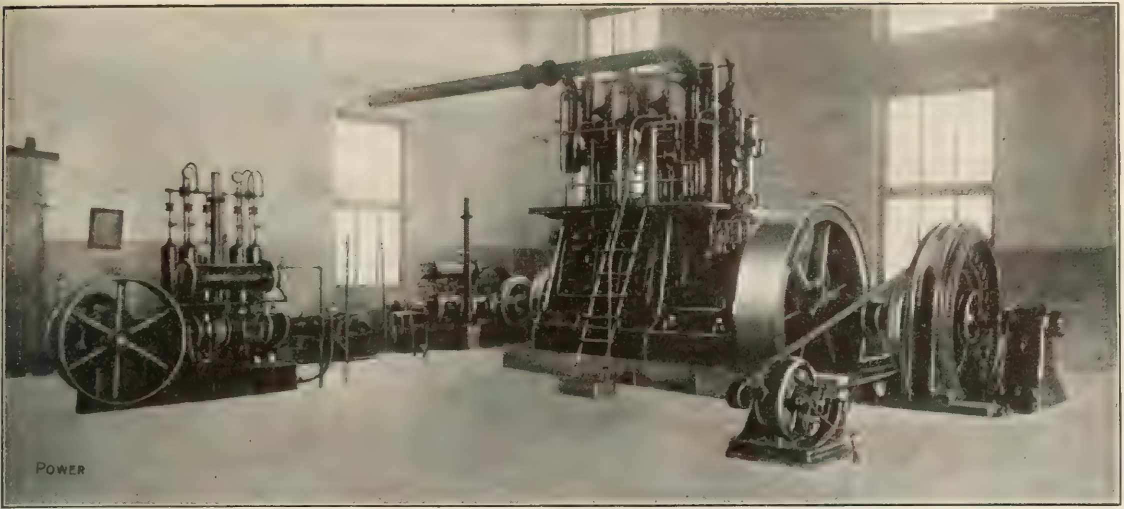


FIG. 3. ONE OF THE MAIN GENERATING UNITS AND THE AIR COMPRESSORS

is near the wall of the building and belt driven by an electric motor.

The object of this arrangement was to permit starting either engine, using the centrally located compressor, and after current was available, to shift to the motor-driven compressor. The wisdom of this procedure is open to question, for when the shift is made there occurs a loss of about 15 per cent. of the power necessary to drive the compressor. This is due to the energy-conversion losses in the electric generator and motor.

PUMPS

The pumps include one 4-in., two-stage centrifugal pump directly connected to a 20-hp., 2300-volt, three-phase, 60-cycle induction motor and four 5-in., three-stage centrifugal pumps directly connected to 75-hp., 2300-volt, three-phase, 60-cycle motors. The 4-in. pump, with a capacity of 250 gal. per min., is used for commercial supply; the 5-in. pumps, each with a capacity of 500 gal. per min., are used in case of fire only. There is no standpipe or elevated tank, consequently the general service and fire pumps are directly connected to the mains and the regulation of the motor of the former is by means of a pressure-control device. All pumping units are in a concrete pit and the suction and discharge nozzles are connected to a common suction and discharge header. Fig. 4 shows the pump pit and Fig. 5 is a detailed drawing of the pipe connections in the pit. By manipulating the valves shown, one unit or all may be put in or cut out of service.

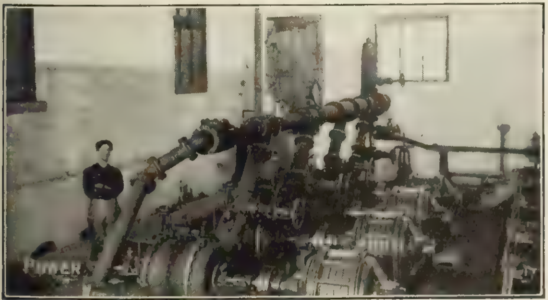


FIG. 4. VIEW OF THE PUMP PIT

When the steam plant was in operation, two 10-in. pipe lines connected the suction of two direct-acting steam pumps with the source of water supply which is in the Mississippi River. When the new plant was installed, in order to avoid the expense of a new suction line, it was decided to connect the old lines, as shown in Fig. 5. Near the pump-suction header, in the pit, a gate valve was placed in each pipe line so that either may be cut out or in at will.

The old pipe lines were in miserable condition, being badly corroded, chocked with silt, and containing many leaks. In consequence, it was difficult to start and operate the pumps until after the imperfections were removed. This cost as much, if not more, in labor, time and annoyance than a new 15-in. line would have cost at the outset.

The water level in the river varies materially throughout the year, and hence the static suction lift of the pumps varies in proportion. This variation amounts to nearly 30 ft. and consequently at low stage the suction lift amounts to 20 ft.; at flood stage there is a head of 10 ft. above the pump suction. A test of the pumps was made at the lowest river stage and before all the imperfections of the suction line had been removed. When all the pumps were in operation a vacuum gage in the suction header read 25 in., showing a total dynamic suction lift of approximately 28.2 ft. The static lift was 20.5 ft. and the difference between this and the dynamic lift represents the loss by friction.

The seven-panel switchboard controls the exciters, generators, motors, four commercial-lighting and three street series-lighting circuits.

COST AND OPERATION CHARGES

The cost of the complete plant, including building, foundations, machinery and installation expenses, was $52,000, and the outside pole line cost $5000. The operating force consists of a superintendent, one night and one day operating engineer, one night and one day oiler, one electrician and a bookkeeper. The salaries paid to

PRINCIPAL EQUIPMENT OF THE ELECTRIC-LIGHT & WATER-WORKS PLANT, DONALDSONVILLE, LA.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Engine	Diesel, 3 cyl.	14x21, 150 hp.	Main unit	Oil.	Busch-Sulzer Bros. Am. Diesel Eng. Co.
1	Generator	Alt. current	125 kv.-a.	Main generator	Directly connected, 2300 v., 60 cycles, 3 phase	Fort Wayne Elec. Works
1	Generator	Direct current	5 kw.	Exciter	Belt driven, 1050 r.p.m.	Fort Wayne Elec. Works
2	Compressors..	Straight line, air	8, 4 and 2, by 5"	Air supply for engines	Belt driven, 200 r.p.m.	Ingersoll-Rand Co.
1	Motor	Induction	25 hp.	Driving air compressor	1150 r.p.m., 3 phase, 60 cycle	Fort Wayne Elec. Works
1	Pump	Two-stage, cen.	4", 250 gal. per min.	Commercial supply	1150 r.p.m., directly connected	Lawrence Pump & Engine Co.
1	Pump	Three-stage, cen.	6", 500 gal. per min.	Fire service	1150 r.p.m., directly connected	Lawrence Pump & Engine Co.
1	Motor	Induction	20 hp.	Driving 4" cen. pump	1150 r.p.m., 3 phase, 60 cycle, 2300 volt	Fort Wayne Elec. Works
1	Motor	Induction	75 hp.	Driving 6" cen. pumps	1150 r.p.m., 3 phase, 60 cycle, 2300 volt	Fort Wayne Elec. Works

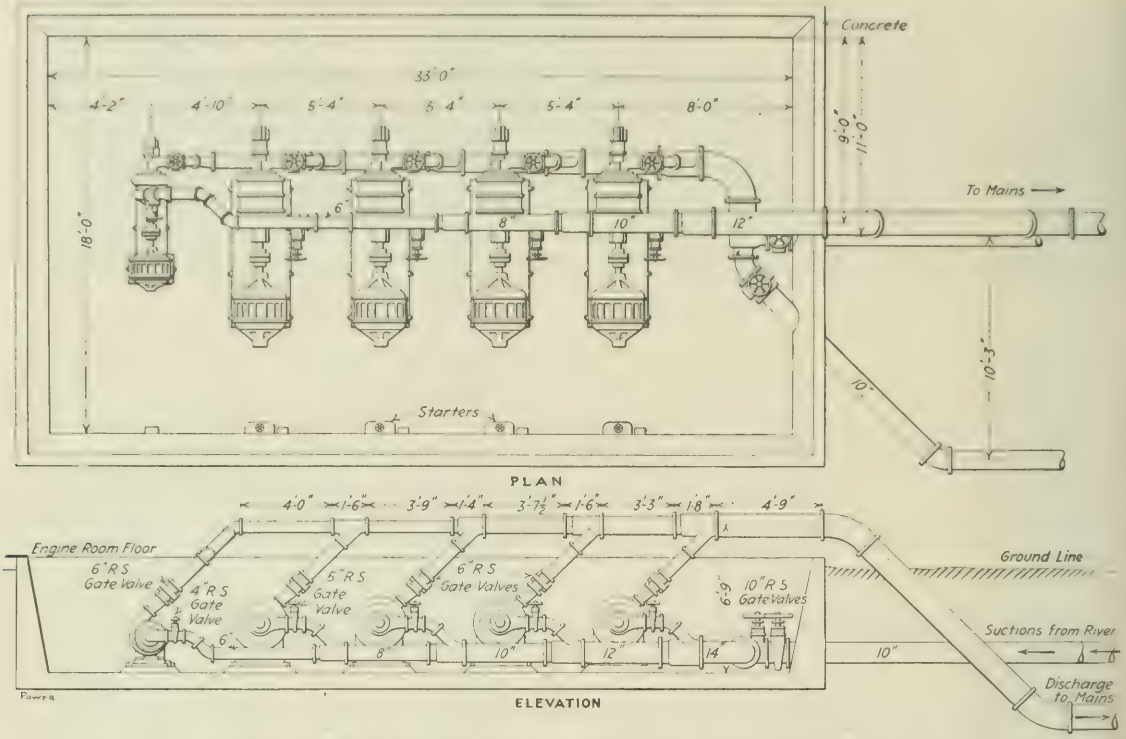


Fig. 5. Plan and Elevation of the Pumps and Their Piping

all total $375 monthly. Fuel oil costs 5c. per gal.; cylinder oil 35c.; air-compressor cylinder oil 50c.; engine oil 23c.; grease 15c. per lb. and waste 10c. per lb.

Superintendent E. A. Thibodeaux has kept an accurate and intelligent record of operating costs since the starting of the plant. The cost record for September, October, November and December, 1913, are shown in the table. The total kilowatt-hour load for each month is also given. Column 13 is the cost per kilowatt-hour in fuel and supplies only; Column 14, the cost per kilowatt-hour in fuel, supplies and labor, and Column 15, the cost per kilowatt-hour in fuel, supplies, labor, interest and depreciation. Interest was figured at 6 per cent. and depreciation at 10 per cent. To this possibly an additional 5 per cent. per annum of the plant cost should have been included for a sinking fund to redeem the bonds at the end of 20 years.

A comparison of this operating cost with that of a steam plant of equal capacity and running under similar load conditions would be interesting. It would be unfair, however, to make such a performance comparison with the old steam plant, because it could in no way be considered as embodying anything like good design or modern practice. For one thing, all the water was formerly pumped by uneconomical direct-acting steam pumps.

DONALDSONVILLE, LA., ELECTRIC-LIGHT AND WATER-WORKS OPERATING COST

1 Month 1913	2 Commercial Load in Kw.-hr.	3 Street Lighting Load in Kw.-hr.	4 Motor Driven Air Compressor Load in Kw.-hr.	5 Motor Driven Pumps—Load in Kw.-hr.	6 Total Kw.-hr. Less Compressor Load	7 Fuel Oil Used During Month, Gal.	8 Cylinder Lubricating Oil Used During Month on Engines, Gal.	9 Engine Oil Used During Month, Gal.	10 Compressor Cylinder Oil Used During Month, Gal.	11 Grease Used During Month, Lb.	12 Waste Used During Month, Lb.	13 Cost per Kw.-hr., Exclusive of Labor, cents	14 Cost per Kw.-hr. Including Labor—Cents	15 Cost per Kw.-Hr. Including Labor, Interest and Depreciation, Cents
September	14,760	7,415	8698	17,320	39,495	4,937 5	127 25	4.0	3.0	6	24	0.75	1.70	3 43
October	15,360	8,270	7650	12,800	36,430	4,582 75	133 50	3.5	3.5	8	34	0.78	1 81	3 69
November	14,410	8,419	4111	18,020	40,849	4,665 5	135 00	7.0	9.0	8	36	0.71	1.63	3 31
December	17,000	9,198	4587	14,850	41,048	4,886 0	141 50	6 5	7 0	8	36	0 74	1 65	3 33
Total	61,530	33,302		62,990	157,822	19,071 75	537 25	23 0	22 5	30	130			

In analyzing these cost data, there are two things to be remembered: The plant is operating considerably below its economical output and this is a disadvantage. Then, too, the plant is new, all pistons, cylinders, valves, etc., are in good condition, and the question arises whether, when the wear comes on, the economy of operation will be maintained for any length of time.

For municipal water-works and electric-lighting service the type of prime mover used in this plant is not particularly adaptable, because of the peculiar requirements. One engine-generator unit is more than sufficient to carry the lighting load and the small motor-driven service pump load. Now power must always be available to operate the motor-driven fire pumps, but these pumps are operated possibly but four or five times a year at the outside, but when operated, both engines must be run in parallel. This means that practically one engine is always idle, with the interest and depreciation charges going on. The other engine is operating for the greater part of the day ridiculously underloaded and, consequently, uneconomically.

Compare this with the flexible steam plant that could have been installed. Suppose that one 50-kv.-a. and one 75-kv.-a., tandem-compound, condensing, single-valve automatic engine, each directly connected to an alternator; a motor-driven service pump, two 1000-gal. Underwriters fire pumps, boilers, switchboard, and all auxiliaries, had been installed and all together, making a simple steam plant. The whole plant complete, including machinery, building, foundations, pipe work and erection, would cost not over $24,000. The smaller engine could take care of the light day, the after midnight and the pumping loads, and the larger engine could carry the peak load. Both operating in parallel could furnish current for any service extension necessary for years to come. The motor-driven pump could supply all commercial needs as now and the Underwriters pumps could remain idle, except in case of fire or drills.

Figuring an average of 25 lb. of steam per indicated horsepower-hour on the engines (which is higher than would actually be consumed) and as low as 6 lb. of water evaporation per pound of coal, and taking into full account all the usual losses and efficiencies, the labor, supplies, interest and depreciation, the cost per kilowatt-hour would be well under 3c. There are steam-engine manufacturers who will gladly guarantee these figures, bond the guarantee and further guarantee to maintain this economy for a period of years.

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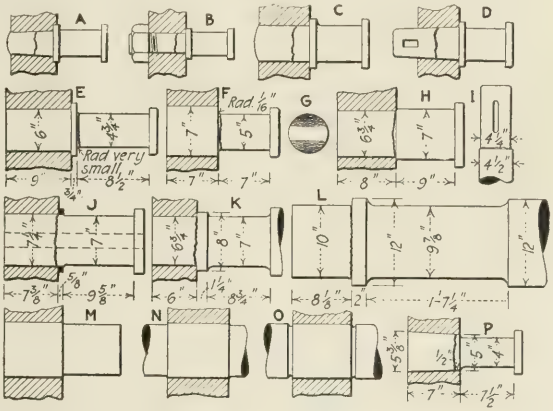
Crankpin Failures

Vice-President Michael Longridge, in a lecture delivered before the Graduates' Association of the Institution of Mechanical Engineers, of Great Britain, thus commented on crankpin designs and failures.

> The history of crankpins has been much like that of cylinders, showing a rising percentage of breakages, culminating in the years 1894-1898, and then falling. The rise was due to bad designing, improper methods of fixing, and overloading; the fall to the more general adoption of the right method of fixing, combined with reduction of stress. In my early days stresses of 12,000 to 14,000 lb. per sq.in. were common, and stresses of 50 per cent. higher were frequently met. Samples of the old designs and methods of fixing are shown. A, B, C and D are examples of pins with conical or cylindrical shanks fitted into the cranks and secured by riveting, screws and nuts, or cotters. They usually broke inside the crank-eyes, because the fit was not accurate enough to prevent slight movements, which wore and enlarged the ends of the crank-eyes next the journals, thus throwing back the point of support and increasing the bending moments. The pins were usually put in from the faces of the cranks, so that they could come out and wreck the engine when they broke. E and F are also typical examples. They have no sharp corners at the junctions of the journals with the collar, though such were not unusual; but the fillets provided, 1/16 to ⅛ in. radius, are too small to be effective. Both pins were of steel. The fractures were due to bending stresses. They commenced at the parts of the circumference nearest to, and furthest from, the crankshaft, and extended inward, as shown on the shaded part of G. The lives of these pins were 14½ and 104 million revolutions, and the bending stresses 17,500 and 11,500 lb. per sq.in., respectively.
>
> The breakage of H may have been entirely due to the abrupt change of diameter from 6¾ in. to 7 in., for piston-rods in direct tensile stress will break with a smaller change than is shown in I; but probably it was started by the shearing action of the edges of the crank-eye when cooling and contracting upon the pin. The failure of the pin J can be attributed to nothing but shear. It was made of steel, of 60,000 lb. tensile strength, 29½ per cent. extension in 6 in., 60 per cent. contraction of area, and a strip, cut out of it after the breakdown, was bent cold nearly double without cracking. It broke under a stress of 9400 lb. per sq.in., after 5¾ million revolutions. I think the crankshafts K and L are similar cases. The stresses and lives were: For K, 8200 lb. per sq.in. and 17 million revolutions; and L, 5000 lb. per sq.in. and 218 million revolutions; the longer life of L was due to the lower stress, and probably to a lower pressure exerted by the crank in cooling. I do not think the effect of the pressure of sharp edges, or even of scratches in starting skin-cracks in steel, or the almost inevitable extension of such cracks under recurrent stresses, is sufficiently appreciated. Of shrinkage, I say without hesitation that the portion of the internal piece upon which an external piece is to contract should be of larger diameter than the adjacent portions, and that the external piece should entirely cover the enlarged portion of the internal. M shows how a crankpin should be put in, while N and O show the proper method of shrinking a piece upon a shaft. It is to the adoption of this principle by many engine makers, combined with reduction of working stress to 8000 lb. or 9000 lb. per sq.in., that the reduction in the number of crankpin breakages must be attributed. The failure depicted in P is one of those things no one can understand.



Crankpin Failures

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Key Soot Blower

The Key soot blower, which was described on page 711 of the Nov. 25, 1913, issue of Power, as the Myers Improved Boiler-Tube Blower, is now manufactured by the Key Tube Blower Co., 21 Park Row, New York City. Some slight changes have been made in the arrangement of the opening in the brick setting at the rear of the boiler, etc., but otherwise the blower is the same as the one described in the earlier issue.

Auxiliary Economy in Steam-Power Plants

By Charles A. Carpenter

SYNOPSIS—A discussion as to the desirability of using economical auxiliaries rather than those known to be wasteful of steam. It is pointed out that a saving is made in power-plant practice by using the former type of apparatus and if the exhaust steam is not sufficient to heat the feed water an additional supply can be bled from the high-pressure stage of the main turbine unit with economical results.

* * *

Auxiliaries of a steam plant, such as pumps, exciters, engines, blowers, stokers, etc., do not develop a horsepower nearly as efficiently as the main generating units. The loss in plant economy, due to inefficient auxiliaries, is not sufficiently appreciated by many operating engineers and it is proposed to point out some of the reasons why low-grade pumps, blowers, etc., reduce station economy and also to show the gain in over-all economy possible with the use of highly efficient auxiliaries, even if it be necessary to bleed steam from the main units for heating purposes.

Waste Heat

The heat in a pound of steam at 150-lb. gage and 100 deg. superheat is roughly 1250 B.t.u. Considering this steam to be used in a turbine exhausting at 28-in. vacuum, 80 per cent. quality, the waste heat is about 900 B.t.u. Thus 72 per cent. of the heat is wasted with the exception of the heat remaining in the condensate, about 70 B.t.u. or 5.6 per cent., which can be returned from the hotwell to the heater, and thence to the boiler.

Under the most favorable conditions

72 — 5.6, or 66.4 *per cent.*

of the heat per pound of steam is carried away by the condensing water. With auxiliaries driven by steam turbines, taking steam from the superheated main supply and exhausting at atmospheric pressure 90 per cent. quality steam, the heat in the exhaust would be about 1055 B.t.u. per pound, or

1055 ÷ 1250 = 84.4 *per cent.*

of the heat remains in the exhaust steam. Should the main turbines run noncondensing, their exhaust would be substantially the same as stated, 80 to 85 per cent. of the heat being carried away in the exhaust.

The efficiency of the main units is high. For an example: Assume the steam consumption as 12 lb. per brake horsepower-hour when operated condensing at 28-in. vacuum, and 22 lb. per brake horsepower-hour when operated noncondensing at atmospheric pressure.

Average auxiliaries would take at least 40 lb. of steam per brake horsepower-hour when run noncondensing. The benefit of having feed water enter the boiler as hot as possible is well known. In a plant using an open heater, 212 deg. is the desirable temperature for feed water. The discussion in this article is based on aiming to get a required load in kilowatts per hour with the feed-water temperature as near 212 deg. as possible with the least amount of steam generated in the boilers.

Without any change in the electrical load on the main units for every 40 lb. of exhaust steam needed for feed water heating, 1 hp. of auxiliaries would be needed in the ordinary method of heating feed water by the exhaust steam from auxiliaries only.

Auxiliary Exhaust

Using the figures already assumed and considering a plant with more efficient auxiliaries which use 35 lb. of steam per brake horsepower-hour, noncondensing, should there be too little steam for heating the feed water, a suitable system for taking steam between the high- and low-pressure parts of one or more main units would be highly desirable. For every 35 lb. of exhaust steam required per hour, one horsepower of auxiliaries would be needed. If there is too little auxiliary horsepower, steam must be bled from the main units to satisfy the requirement of heating of the feed water to 212 deg.

To supply 35 lb. of atmospheric-pressure steam by bleeding it would be necessary to develop 1.6 hp. by bleeding the noncondensing high-pressure part of the main unit. The noncondensing water rate being 22 lb. per b.hp.-hr.,

35 ÷ 22 = 1.59

or 1.6 hp., approximately.

The loss in economy due to noncondensing operation is

22 — 12 = 10 *lb.*

of steam per brake horsepower-hour, or 16 lb. for 1.6 hp. Therefore, for every 35 lb. of atmospheric-pressure steam supplied by bleeding, only 16 lb. can be charged against the heating operation, as the remaining 19 lb. would have been used for power had no bleeding taken place. Consequently a gain of 19 lb. is effected in the total plant economy for every 35 lb. of steam bled from the main units and utilized for heating.

Assume a plant using 300,000 lb. of steam per hour for the main units at normal load and 40,000 lb. of steam per hour additional for the auxiliaries. If the feed water be completely heated and the auxiliaries require 40 lb. of steam per brake horsepower-hour, 1000-hp. auxiliaries would be operated.

In a plant having more efficient auxiliaries using 35 lb. of steam per brake horsepower-hour, 35,000 lb. of exhaust would be available. As 40,000 lb. are required for complete heating of feed water, 5000 lb. would be required from a bleeding process. This would require operating

5000 ÷ 22 = 227.3 *hp.*

exhausting at atmospheric pressure with an increased steam consumption of

10 × 227.3 = 2273 *lb. per hr.*

The difference between 5000 and 2273, or 2727 lb. of steam per hr., would be saved. This only represents $^8/_{10}$ per cent. saving for the whole plant, but considering steam worth 0.12c. per 1000 lb., the gain would be 32.72c. per hr., or about $2800 per year.

The saving in steam at normal load is by no means the only advantage of economical auxiliaries. Low loads in most plants are accompanied by steam wasting from the heaters. High loads are frequently the cause of feed water entering the boilers only partially heated. A reliable bleeder system with economical auxiliaries would save steam under each of these conditions. The chance of having too much atmospheric exhaust at low loads would be reduced, because of the reduced amount of exhaust available. At high loads increased bleeding would insure the feed water being completely heated.

The percentage of total heat in a pound of steam available for power is small as compared with the amount necessarily wasted. In order to get all possible power out of steam, high-vacuum condensing operation has been proved best. At the same time a more important item presents itself. This small amount of heat available for power may be wasted in apparatus which is inefficient in its utilization of the heat supplied. The heat so wasted in windage, friction, etc., cannot be recovered except to a small extent in a tendency to improve the quality of the exhaust steam by the heating effect of friction.

Best Results

In order to get the best results in a plant for heating purposes only, noncondensing operation generally proves the most economical. The small amount of heat extracted for power purposes, such as driving feed pumps, etc., leaves the greater part of the heat available for heating. The use of live steam under such circumstances is a costly method. Even in this case if steam at boiler pressure can be used in the heating systems, efficient utilization of steam in the pumps, etc., is desirable, as it further minimizes the heat extracted for power, leaving more available for the heating and so requiring a less supply from the boilers.

The main feature of power-plant practice is power, but it must not be forgotten that steam is needed for heating feed water and possibly for heating buildings in winter. Why use inefficient auxiliaries which waste a large amount of heat in useless effort, merely to supply sufficient exhaust steam for heating, when operating part of the power units noncondensing supplies equally desirable exhaust with the advantage that the high-pressure part of the heat in the steam has been used efficiently to develop salable power.

Electrically Driven Auxiliaries

The arguments in favor of auxiliary economy may lead to the belief that electrical auxiliaries are advantageous. Such is not generally the case. Referring to the first part of this article, it was shown that 84.4 per cent. of the heat in one pound of steam at the boiler remains in a pound of exhaust steam at atmospheric pressure and 90 per cent. quality. As long as this steam can be used for heating purposes to advantage, only 15.6 per cent. of the total heat can be charged to the power units. Thus with auxiliaries using 40 lb. of steam per brake horsepower-hour, only

$$0.156 \times 40 = 6.24 \textit{ lb.}$$

per hour are chargeable to power as long as exhaust steam is to be used for heating. The instant steam blows to waste from the heating system, 40 lb. of steam per horsepower-hour are correctly chargeable for each horsepower of exhaust so wasted.

Electrical auxiliaries in a plant, such as assumed in the foregoing, would require not less than 16 lb. of steam per horsepower-hour, considering motor efficiency, transmission losses, etc. Therefore, steam auxiliaries show a gain of

$$16 - 6.24 = 9.76 \textit{ lb.}$$

of steam per hour, as long as the exhaust can be used. When the exhaust must be wasted, the electrical auxiliaries would gain

$$40 - 16 = 24 \textit{ lb. per hp.-hr.}$$

for every horsepower of exhaust steam so wasted.

Reducing Auxiliary Steam Consumption

The question now may be raised, how may the total steam used by auxiliaries be reduced? The first step is to create a demand for more economical pumps, blowers, etc. A second move is to carefully analyze auxiliaries in a plant so as to use pumps, blowers and stokers more nearly at their best efficiencies. Throughout all it must be remembered that steam uselessly wasted in developing power either for sale or for auxiliaries never pays dividends and consequently the argument that auxiliary economy is no object is a fallacy to be shunned by engineers.

* *

Bending Action of Butt-Strap Joints

By F. W. Dean

SYNOPSIS—The common forms of butt-strap joints, like lap joints, are likely to cause bending and cracking of the shell plates of boilers. The author points out forms of butt straps and riveting to reduce the danger.

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Articles recently published referred to the importance of reducing the weight of locomotive boilers, but no study appears to have been made of the longitudinal joints of boilers for reduction of weight.

Boilers do not explode because the plates are too thin, but because they are so made in some part that the material bends back and forth and finally cracks where the bending is a maximum. A boiler built with lap joints usually explodes because the plates are bent at the edge of the joint with every change in pressure. The effort of the boiler to become circular with increases of pressure, and to take its original form with decreases of pressure, finally results in cracking the plate. The same thing takes place in the drums and other parts of water-tube boilers.

Few American horizontal return-tubular boilers built with butt joints have failed in the butt and strap joints, although at least two have cracked at the edges of the joints sufficiently to cause audible leakage. In these cases pressure was immediately reduced and explosions were prevented. More such cases may be expected and there may be a few explosions. The trouble with butt joints is that, as usually designed, they possess a feature which causes bending of the plate with changes in pressure, just as in the case of lap joints, though to less extent.

Butt joints are usually so designed that they are not equally strong on both sides of the plate, and the joint bends as the pressure increases, and returns as it decreases. Some years ago the writer designed several wide joints and tested them to destruction on the large testing machine at the Watertown Arsenal. The joints tested were so wide that it required from 350,000 lb. to 450,000 lb. to break them. While under strain they always took the form shown in Fig. 1, and the distance *a* was about $\frac{3}{16}$ in. when they broke. The significance of this behavior was not appreciated until information was received of the cracking of the plates in the two butt-joint boilers referred to. The one sided feature of the joint caused the bending, the bending caused the cracks, and cracks thus formed in a boiler joint would have caused an explosion unless sooner detected by the escape of steam.

Since making the tests the writer has required the butt straps of boilers on the opposite sides of the plates to be of the same width and the rivets in double shear. The straps have been made as narrow as possible in order to have the rows of rivets as near together as practicable so that the inside strap, which is not calked, would have small opportunity to straighten out, due to the curvature of the shell between rows of rivets, and to further diminish this action the inside straps have been made thicker than usual.

Figs. 2 and 3 show such joints, Fig. 3 showing the better design. The latter joint can be made with an efficiency of 92 per cent. or more. The joint in Fig. 1 can be theoretically of this efficiency, but its one-sided feature is misleading.

My first knowledge of the type of joint shown in Fig. 3 was received from the illustrations of the boilers of the steamship "Kaiser Wilhelm der Grosse," which were published nearly twenty years ago. This is illustrated in Fig. 4. The fault of the design is that the straps are too wide and the rows of rivets parallel to the axis of the joint are too far apart.

One is led to the conclusion that the plates of the cylinders of boilers can be made thinner than usual by the use of non-one-sided or symmetrical butt joints. The factor of safety employed is a matter of guess work, and if it is a "factor of ignorance" the "ignorance" is largely removed by the use of the symmetrical joint. Except to guard against corrosion, there seems to be no reason why the factor of safety should be more than three to four in a boiler built with the joint advocated, and considerable weight can be saved. Other parts of the boiler should be studied so as to avoid places where bending can take place.

In this connection it is well to note that failures of dished heads in boilers, whether water or fire tube, are often caused by bending at the edges where the heads are flanged to join the shell. Many designers of boilers appear to be satisfied if they make these heads segments of spheres, but such heads differ but little from flat ones in this element of weakness and need nearly as much bracing to prevent their bending at the turn of the flange. In Germany, Lancashire boilers are made with dished heads, but as the ends are tied together by the furnaces there is scarcely any liklihood of rupture in this manner. Designers of dished heads for pressure vessels should remember that such heads will bend at the edges and almost surely crack in time and probably could be removed from the dangerous class only by making the heads hemispherical.

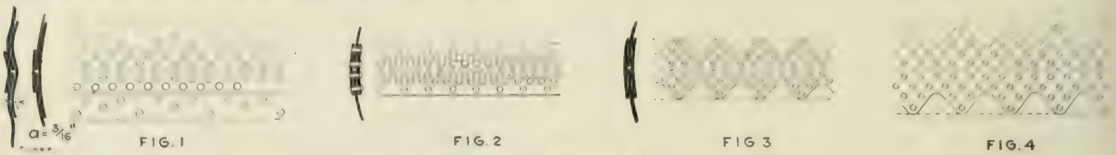

FIG. 1 FIG. 2 FIG. 3 FIG. 4

TYPES OF BUTT AND DOUBLE STRAP JOINTS

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Oil-Fuel Service at Fort Baker

BY O. W. DEGEN*

A new field of application in the use of oil fuel has been introduced by the government at Fort Baker, Calif. Just as it is customary to distribute water and gas throughout a town for commercial and domestic purposes, the fuel oil is here piped through the streets and delivered to residences, and other buildings under a pressure of 30 lb., where it is used in furnaces for heating and cooking, and in oil engines for power. This and the installation now about completed at the Presidio, San Francisco, are believed to be the first of their kind attempted on a large scale. The system consists of oil-supply pipe lines, oil-storage and distributing reservoirs, oil pumps and motors, air pipe lines, compressors and oil burners.

The oil is delivered by tank steamer and is pumped through a 6-in. pipe to a storage reservoir of 100,000 gal. capacity at an elevation of 100 ft., this being the limit to which it is desirable to pump from the steamers. The reservoir, as indicated in the illustration, is constructed in red rock, lined with 5 in. of concrete on the sides with wire fabric as reinforcing; the interior was sprayed with cement gum and is roofed over. From this storage reservoir the oil is pumped into a distributing reservoir of 10,000 gal. capacity at an elevation of 200 ft., and from here it is distributed through 4-in. wrought-steel pipes throughout the entire reservation, except the branches to houses, which are 2 in.

Care had to be taken to have the pipe lines tight, and provide for expansion and contraction by inserting U-bends bedded in sand every 300 ft. Gate valves are distributed throughout the system, so any part can be shut off without interfering with the rest.

All the burners for the boilers, hot-water heaters, ovens, etc., are of the air-mixing type. The air lines are laid in the same trenches as the oil pipes, and range in size from 8 in. at the compressor end to 2½ in. at the house tops. Two motor-driven centrifugal air compressors, each with a capacity of 750 cu.ft. per min. furnish air under about 2 lb. pressure.

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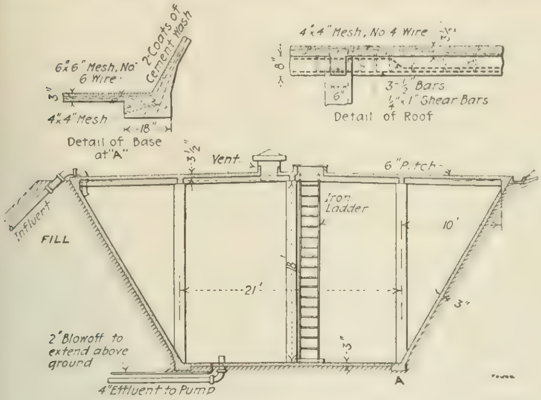
*Civil engineer, War Department.



SECTION THROUGH STORAGE RESERVOIR

California crude oil is used with a heat value of 18,000 B.t.u. and a specific gravity of 0.966. One gallon of this oil requires 1875 cu.ft. of air for combustion. The oil costs 1.9c. per gal. and its use shows a saving of 76 per cent. over coal. The cost of the two oil tanks and pumping machinery was $4350; the oil pipe lines $1295; and air lines, compressors and burners $6380, or a total of $15,025 for the entire installation. The cost per hour for an army range using 1½ gal. of oil per hour is about 3c., including the cost of electric current for driving the compressor.

The installation has been a complete success and is much preferred by the soldiers to burning coal. It requires very little labor and is extremely clean as there are no ashes nor smoke.

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Heating and Ventilating Loft Buildings

By Charles L. Hubbard

SYNOPSIS—Loft buildings are subject to frequent changes of subdivisions and of tenants and the author points out the types of heating and ventilating apparatus which are readily adapted to different requirements.

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Loft buildings are included in a class of buildings used principally for mercantile and light manufacturing purposes.

The varied character of the work and the frequent changing of tenants usually makes it impossible to install a permanent system of ventilation as may be done in case of a store or factory building. Under usual conditions the owner provides heat, elevator service, and sprinkler equipment, together with the necessary power for their operation.

Electricity is commonly generated upon the premises and sold to the tenants for power and lighting, while in connection with this, both live and exhaust steam are supplied on each floor for manufacturing or other purposes.

HEATING

Buildings of this type are commonly heated by direct steam, the coils or radiators being placed along the outer walls beneath the windows. Automatic temperature regulation is not usually provided, partly on account of the expense and partly because the rooms, being large, usually contain several radiators, thus giving a certain amount of hand control. In some cases, where the floors are not divided by partitions, unit hot-blast equipments are provided of sufficient capacity to do a portion of the heating, thus reducing the amount of direct radiating surface required. This can only be done to advantage when the use of a given floor is to be permanent, or at least is to remain the same for several years. As buildings of this kind are not generally heated during the night, it is necessary to provide means for quick warming in the morning, which makes it advisable to employ some form of vacuum system for producing a rapid circulation through the radiators.

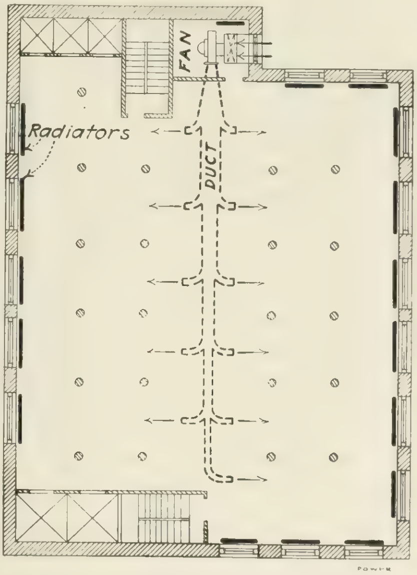


FIG. 1. TYPICAL LAYOUT FOR HEATING AND VENTILATING A SINGLE FLOOR

When the coils and radiators are of large size, the best results are obtained by connecting a vacuum pump with the main return, or a single-pipe system with a vacuum air line proves satisfactory. In laying out the piping, special supply and return risers should be carried to the top of the building, with outlets on each floor, to provide steam for ventilation, should this be furnished later.

VENTILATION

The ventilating equipment in loft buildings is usually installed by the tenants in order that it may be adapted to their special needs. There are two common methods employed, one being to force in tempered air, allowing it to find its way out by leakage or through open windows, while the other makes use of an exhaust fan which produces a slight vacuum within the room, thus causing fresh air to enter through induction heaters placed in front of windows in different parts of the room.

The first method is usually favored by engineers, as being more easily controlled and giving a rather better air distribution when properly installed. In order to give the best results, however, provision must be made for the outward flow of air either through elevator shafts and stairways or by slightly opening the windows on the leeward side of the building.

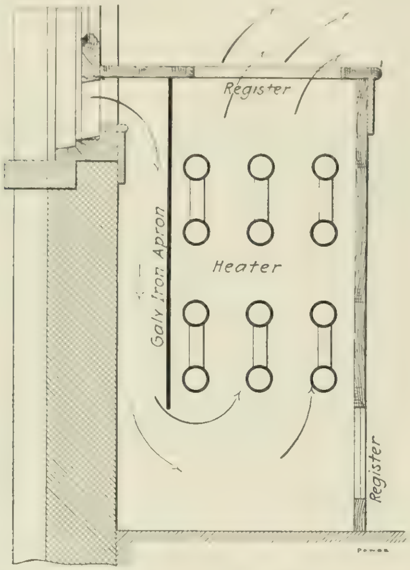


FIG. 2. FRESH-AIR INLET FOR VENTILATION BY EXHAUST FAN

A typical layout for the heating and ventilation of a single floor in a loft building, where there are no partitions, is shown in Fig. 1. The room is warmed by wall radiators placed beneath the windows and the temperature controlled by means of hand valves.

The ventilating equipment consists of a steel plate blower driven by a direct-connected motor and connected with an encased heater of sufficient capacity to warm the entering air to 72 deg. in the coldest weather.

The fan and heater are mounted upon a platform suspended from the ceiling of the toilet room, and therefore do not require any space which may be utilized for other purposes. The air distribution is through a galvanized duct at the ceiling, with outlets discharging toward the outer walls.

When the space is divided by partitions the ducts must be laid out in such a manner as to give each room its proportion of fresh air. Rooms devoted to manufacturing processes requiring special conditions as to temperature and humidity must be heated independently.

When the exhaust method of ventilation is made use of, instead of the plenum, it is evident that provision must be made for supplying an amount of tempered air equal to that discharged by the fan.

An arrangement for this purpose is shown in section in Fig. 2, and consists of a double bank of indirect radiator sections, placed before a window, and so encased that the entering air must pass through them before reaching the room. The volume of air admitted is governed by the height to which the sash is raised or a special adjustable damper may be placed in the inlet opening.

Temperature regulation may be secured by valving the heater in sections or by the use of a mixing damper. During such times as ventilation is not required, the window may be closed and the register in front of the casing, near the floor, opened to produce a rotation of air through the heater. A sufficient number of these induction stacks should be provided to supply the required amount of tempered air, and they should be so placed as to diffuse it as much as possible.

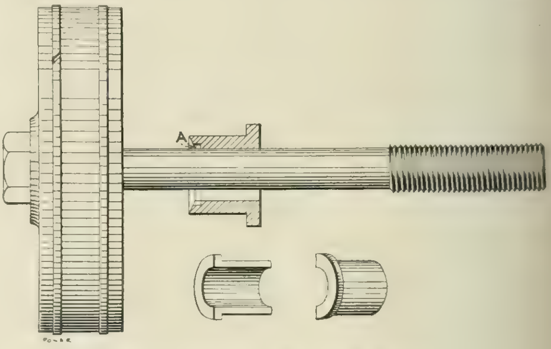
Loft buildings are commonly furnished with 25 to 30 cu.ft. of air per occupant per hour.

*

Bushing a Piston-Rod Gland

While overhauling an old engine an engineer unscrewed the piston rod from the crosshead and attempted to remove the stuffing-box gland, but the end of the piston rod was too large to let the gland slide over. As the gland was not clean, it appeared to be in one piece only. To tell how it was put on without disconnecting the piston from the rod was a puzzle. After cleaning and examining the gland thoroughly, it was found that it contained a split bushing, the halves of which are shown in the illustration. When this bushing was taken out the gland could be easily removed.

This rod was badly scored, making it necessary to turn it down to secure a smooth surface. Had it been turned down over the entire length, the threaded part would have been too small for the crosshead; therefore it was turned down only where scored, and a split bushing fitted to the gland. Such a bushing should always be made of brass, because cast iron is likely to score the rod, and it is easily broken in service as it would be quite thin. Turn a recess at the inner end of the gland, as shown at *A*, with a corresponding head on the bushing. The former will receive the latter and prevent it from blowing out under pressure.



SPLIT BUSHING FOR PISTON ROD

The Induction Motor--VIII

By F. A. Annett

SYNOPSIS—The different methods employed to vary the speed of polyphase induction motors and their relative advantages. Also as the concluding article of the series a general summary of the applications of induction motors is given.

* * *

Variable-Speed Alternating-Current Motors

Variable-speed motors, whether direct or alternating current, may be divided into two classes, varying-speed and adjustable-speed motors. Varying-speed motors are those the speed of which varies with the load, but is constant with constant loads, such as direct-current series motors. Adjustable-speed motors are those in which the speed is practically constant at any adjustment irrespective of the load, such as direct-current shunt motors.

An alternating-current motor, in general, is distinctly inferior to the direct-current machine for adjustable-speed service, although a polyphase induction motor can be built that compares quite favorably with the direct-current shunt motor. This, however, requires expensive and complicated construction and up to the present time it has not been used to any extent.

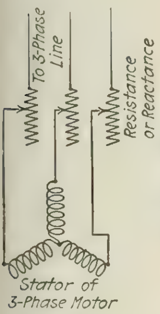


Fig. 75

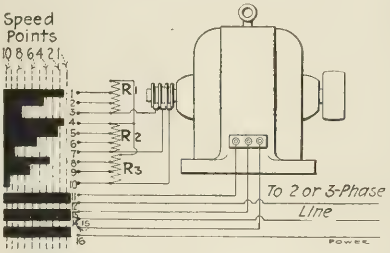


Fig. 76

Fig. 75. Starting with Resistance or Reactance in Line.
Fig. 76. Wiring Diagram of Controller.

The speed of polyphase induction motors may be changed by several methods of which the following are the most important:

1. Adjusting the voltage applied to the stator terminals.
2. Adjustable resistance in the rotor circuit.
3. Changing the number of poles.
4. Operating two motors connected in cascade.
5. Using two motor stators in one field frame, one of which can be revolved.
6. Changing the frequency of the primary circuit.

Adjusting Voltage across Stator Terminals

This adjustment can be obtained by connecting a resistance or reactance in series in the line, as in Fig. 75, or by the use of an autotransformer; but this method of speed control is unsatisfactory and is seldom used. The speed regulation is poor, and the efficiency and power factor decreases rapidly as the speed decreases, the efficiency decreasing more rapidly than the speed. The torque decreases as the square of the voltage decreases; that is, if the voltage is decreased by two the torque decreases by four. Therefore, if the voltage is greatly reduced the motor becomes very weak and unstable in its operation. Also, a small increase in the load will cause a great decrease in speed and may cause the motor to break down and stop.

Adjustable Resistance in Rotor Circuit

The electromotive force set up in the rotor of an induction motor depends upon the difference in speed between the stator magnetic field and the speed of the rotor itself, or as it is called the "slip." If the resistance of the rotor is low the e.m.f. generated in its conductors, necessary to set up a current that will develop a torque sufficient to carry a given load, will be correspondingly low; therefore, the difference in speed between the stator field and the rotor will be small. On the other hand, if the rotor resistance is increased, the e.m.f. will have to be increased in proportion to the resistance to set up the same current in the rotor conductors as before; therefore, the slip between the rotor and stator flux will be increased; that is, the motor will slow down. This fact is taken advantage of to vary the speed of the polyphase induction motors, and is accomplished by using a phase-wound rotor with slip rings and an adjustable external resistance as described in Part 2 (Oct. 21, 1913). In this case, however, the resistance must be large enough to carry the full-load current continuously, and if the motor is large the resistance for variable-speed service becomes very large and expensive.

To obtain several adjustments in speed and keep the resistance balanced in each phase of the rotor will require a controller with a large number of contacts for at each change of speed an equal amount of resistance will have to be cut out of each phase and with a controller of 12 contacts if the resistance is kept balanced at all times it would only be possible to obtain five adjustments of speed. This in most cases is impractical and therefore the controller is arranged as shown in Fig. 76, so that the resistance can be changed successively in each of the three sets of resistance and instead of obtaining five adjustments of speed by the arrangement previously mentioned it is possible to get 10 adjustments of speed with a 10-contact controller. By the addition of six more contacts, as shown at the bottom of the diagram, it is also possible to control the primary circuit. It will be seen that when the controller is on point 1, contacts 11 and 12, 13 and 14, 15 and 16 respectively are connected together. This closes the stator circuit to the line and the motor starts with all the resistance in the rotor circuit; at this point the rotor resistance is balanced. When the controller cylinder is moved to speed point 2, it makes contact with points 1 and 4 of the rotor resistance and cuts out one section of R_1. At point 3, contact 5 comes into service and cuts out one section of R_2. Likewise at point 4, contact 8 touches the cylinder and cuts out one section of R_3. At this point the resistance is again balanced; this condition is found again at points 7 and 10. The points where the resistance is balanced are considered the best for continuous operation, although the motor may be operated at anyone of the intermediate points. With slight modifications this controller can be made reversing.

The speed-torque characteristics of an induction motor controlled in this way are similar to those of the direct-current machine which has its speed controlled by a resistance in series with the armature. If the load is constant the speed of the motor increases as each step of the resistance is cut out and remains constant at any position of the resistance, but if the load is varying the speed changes inversely as the load, and if the load is removed entirely the speed increases to almost synchronism. Although this motor is not suited to service that requires a constant speed under varying loads, such as machine-tool work, this method of speed control is useful where constant speed is not essential and efficiency is of secondary importance. At one-half normal speed the efficiency is one-half normal and for other speed settings it is proportional.

Changing the Number of Poles. This method of control is used extensively in medium-sized motors where practically a constant speed is required irrespective of load. The synchronous speed of an induction motor depends upon the number of poles in the stator winding and the frequency of the line and can be expressed as follows:

$$S = \frac{120\,f}{p}$$

Where

S = Revolutions per minute;
f = Frequency, cycles per second;
p = Number of poles.

Example. A two-pole motor connected to a 25-cycle circuit will run at a speed of

$$S = \frac{120 \times f}{p} = \frac{120 \times 25}{2} = 1500\ r.p.m.$$

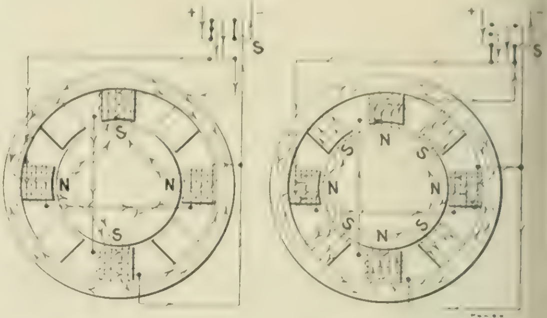
If the number of poles are changed from two to four the speed will be

$$S = \frac{120\,f}{p} = \frac{120 \times 25}{4} = 750\ r.p.m.$$

That is, increasing the number of poles by two decreases the speed by two and *vice versa*. This is true for any number of poles.

An induction motor may be constructed with two distinct windings, each wound for a different number of poles, and will operate at two different speeds, corresponding to the number of poles in either winding respectively. This motor will have two outputs corresponding to the two speeds; if the speed is reduced by one-half, the output will be reduced by one-half. There are several elements that enter into the design of such a motor that are antagonistic to its construction and satisfactory operation and it is, therefore, little used. The method usually requires but one set of coils, connected in such a way that by use of a special switch they may be connected so as to change the number of poles.

In Fig. 77 is represented an eight-pole direct-current field frame with four field coils located as shown and connected to a double-pole double-throw switch S. When the switch is in the up position the field coils are connected in series multiple, and the current is in such a direction in each coil that will produce north and south poles, as shown; therefore, the lines of force will take the path indicated by the dotted lines, thus forming four poles. When the switch S is in the down position, the field coils are in series and the current will produce a north pole in each of the four polepieces carrying the field coils. The flux from the north poles will flow in the path indicated by the dotted lines, which will induce south poles in each of the polepieces between those carrying the field coils, as shown in Fig. 78; thus converting the field frame into one that has eight poles instead of four. This is the method used in a pole-changing induction motor, but as the coils are distributed symmetrically over the stator core of an induction motor it will not be necessary to leave blank polepieces for the larger number of poles.



Figs. 77 and 78. Illustrating Principle of Pole Changing Motor

Fig. 79 shows diagrammatically the stator winding of a two-phase four- to eight-pole induction motor. By tracing the current when the four-pole double-throw switch S is in the up position, it will be found that the current will be in such a direction as will produce alternate north and south poles and the winding will produce four poles as described in Fig. 77. When the switch is in the down position the coils will be in series, with the current flowing in the same direction in each coil, which will produce four like poles in the winding. These will induce poles of the opposite polarity between the field coils, as described in Fig. 78; the winding will be converted into one of eight poles, and the machine will operate at one-half the speed and capacity as when it was operating as a four-pole machine.

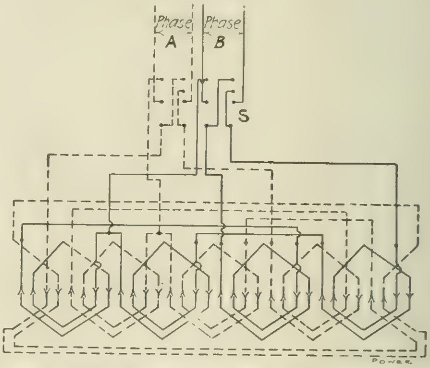


Fig. 79. Stator Winding of Changeable-Pole Motor

To change the number of poles of the stator winding without changing the rotor winding the motor will have to be of the squirrel-cage type, for the squirrel-cage winding automatically adjusts itself to any number of poles. If the rotor is of the phase-wound type it will have to be wound to conform with the number of poles in the stator winding which means that if the number of poles are changed in the stator the number of poles will have to be changed in the rotor, which in the case just described will require the use of six collector rings.

Motors Run in Cascade. If the rotor of a phase-wound induction motor is locked so that it cannot turn and the stator winding is connected to a source of alternating current it will be found that there is developed at the collector rings of the rotor an alternating e.m.f. of the same frequency as that of the line. If the rotor winding has the same number of turns as the stator, theoretically the rotor e.m.f. will be equal to that applied to the stator terminals. On the other hand, if power is applied to the rotor and it is run up to synchronous speed it will be found that the frequency and e.m.f. has decreased to zero. At any intermediate point the voltage and frequency will be in direct proportion to the slip. For instance, if sufficient resistance is connected in series with the rotor so that it will operate at half speed the e.m.f. and frequency will be one-half that of the line. From this it is obvious that instead of using up this energy from the rotor in a resistance it might be used to operate another motor. This can be done, and when two or more motors are connected in this way they are said to be in "cascade." Fig. 80 shows two polyphase induction motors connected in this manner. The stator of motor No. 1 is connected to the mains with its rotor connected through a variable resistance R to the stator of motor No. 2, and the rotor of motor No. 2 is connected to a variable resistance R^1. The resistance may be omitted and a squirrel-cage rotor used in motor No. 2. The different speeds that the set can operate at under this condition will be fixed by the synchronous speed of the various combinations.

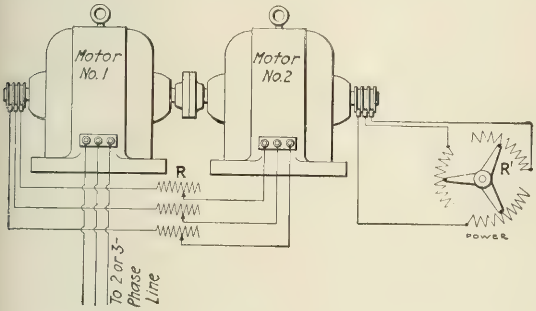


Fig. 80. Motors Connected in Cascade

For the successful operation of this method the rotors of the two motors must be connected mechanically. In this way they can be made to operate at practically constant speed. When connected in cascade and in direct concatenation the speed of the set will be the same as that of an induction motor having a number of poles equal to the sum of the poles of the two motors. For example, consider that each motor has the same number of poles the speed of the set will be half that of one motor if operated alone. Suppose the speed of motor No. 1 is greater than half speed, then the frequency applied to motor No. 2 will be less than half that applied to motor No. 1. By applying the formula for the speed it will be found that the rotor of motor No. 2 is revolving faster than the stator-magnetic field; then the rotor conductors will be cutting the stator flux in the opposite direction and the current in the rotor will be reversed; consequently the torque. This will cause the set to slow down until the rotor frequency of motor No. 1 is the same as the frequency corresponding to the speed of motor No. 2. From this it will be seen that the speed of motor No. 1 must be such that the frequency of the rotor corresponding to its speed of rotation is approximately the same as the frequency corresponding to the speed of motor No. 2.

When two induction motors are connected in cascade so that they tend to start in opposite directions they are connected in differential concatenation, and the speed of the set will be equal to that of a motor having a number of poles equal to the difference between the number of poles of the two motors.

If the motors are wound with a different number of poles; for example, No. 1 with four poles and No. 2 10 poles, four different individual synchronous speeds may be obtained for the set. For No. 1 and No. 2 motors are connected in direct concatenation the synchronous speed of the set will be that of a motor having a number of poles equal to that of the two motors, or a 14-pole motor, which on a 40-cycle circuit would have a synchronous speed of 343 r.p.m. If the 10-pole motor is operated alone, its synchronous speed will be 480 r.p.m. Connecting the two motors in differential concatenation the set will have a synchronous speed of a six-pole motor, or 800 r.p.m.; and when the four-pole motor is connected to the line alone it will have a synchronous speed of 1200 r.p.m. If a resistance is used in the rotor circuits, as shown in Fig. 80, a gradual variation in speed may be made from one synchronous speed to the other.

This method of speed control is simple and may be used under some conditions of service quite conveniently. One of the objections to it is the low power factor of the set when operated in cascade. This is apparent as both machines are operating with full field flux in the stator; therefore they will require twice the excition current of one machine operating alone, and the power factor will be correspondingly reduced.

Two Stators in the One-Field Frame. By using two stators, each with its separate core and winding in the one-field frame, one arranged so that it can be revolved around the rotor by a worm-gear device, the speed of an induction motor can be varied through a wide range. The rotor also has two separate cores with but one squirrel-cage winding, the bars of which extend straight through the two cores to the short-circuiting rings at the out end of the rotor. When the two halves of the stator are so placed that like poles act upon the same rotor bars a maximum current will be induced in the rotor winding and the motor will run at a maximum speed which will be near synchronism. By gradually turning the movable half of the stator the flux from opposite poles in the stator windings is made to act upon the same bars in the rotor. This will induce opposing e.m.f.'s in the rotor winding, which will reduce the secondary current and will consequently cause the motor to slow down.

Adjusting Frequency of Primary Circuit. This is done by a frequency changer driven by variable-speed direct-current motor. This method can be used in places where it is not desirable to use a direct-current machine.

SUMMARY

Summarizing the alternating-current motor we find that for certain classes of service the polyphase squirrel-cage induction motor possesses certain distinct advantages. Among these are ruggedness and simplicity of construction, the absence of all moving contacts, low maintenance charges, and ability to stand hard usage with a minimum attention, which makes it an ideal motor for use in cement mills, flour mills, sawmills, textile mills, steel mills, or any place where it is very dusty, dirty and damp, and to drive machinery that requires a fairly constant speed without excessive starting torque.

Against the polyphase motor may be mentioned the following: Excessive starting current with only a fair starting torque, requiring about 260 to 300 per cent. full-load current to develop 100 per cent. full-load starting torque; low power factor; its speed is not readily adjusted (being fixed by the number of poles and the frequency of the line); and it requires special construction when variable or adjustable speed is required, which under the best of conditions does not compare favorably with the direct-current machine.

As far as the motor is concerned it may be connected direct to the line at starting, but to protect the machine that the motor is starting, which might be injured by too rapid acceleration and to keep down the starting current (which may amount to 600 or 700 per cent. full-load current if the motor is connected direct to the line), a starting device is usually required on motors above 5 hp. This starting device is usually an autotransformer or resistance in the primary circuit. The autotransformer is given the preference where minimum starting current with maximum starting torque is of primary importance, and the resistance for motors up to 25 hp. where first cost is the most important factor.

A special starting device may be used, such as additional turns on the stator winding, which are in circuit at starting and are cut out after the motor has come up to speed. The stator windings may be connected in star at starting and delta when running, or may be divided into two equal parts which are connected in series at starting and multiple when the motor has been accelerated. Where the machine to be started possesses large static friction or inertia, or the accelerating characteristics require a large starting torque with a minimum current, a wound-rotor motor should be used. This type will develop about 100 per cent. full-load starting torque with 100 per cent. full-load current, and other torques in proportion to the starting current until a maximum torque is obtained. When compared with the squirrel-cage motor the wound-rotor machine is found to be inferior in every respect except that it has much superior starting characteristics.

Special conditions are met in practice which require motors both of the squirrel-cage and wound-rotor type of special construction. For driving a loom a motor that starts with a strong effort must be used where one that starts slowly and smoothly must be used on a warper. In steel and iron mills motors that are of extremely rugged construction and able to withstand the roughest handling and capable of being repaired in the shortest possible time in case of accident should be installed.

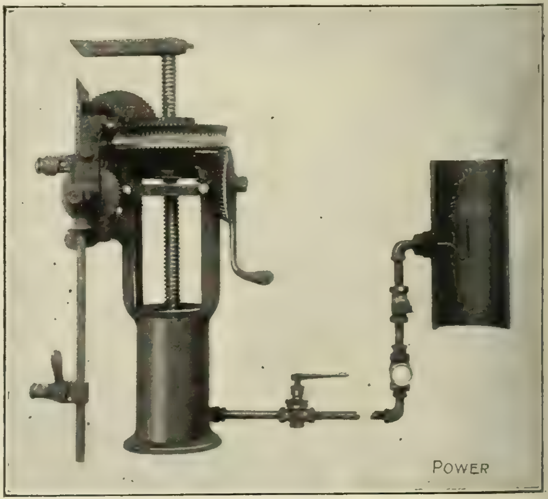
Although there are sound engineering reasons for the use of single-phase motors their use is usually confined to systems where single-phase current only is available. The single-phase motor for general use is not self-starting, therefore, some means must be provided to bring it up to speed. The most important of the starting devices are the shaded-pole, the split-phase and the repulsion methods. The shaded-pole motor is confined to driving small fans and is not of much significance. The split-phase motor is usually limited to sizes up to 5 hp. and to drives that do not require large starting torque and where a large starting current is not objectionable. Where the load has considerable static friction and inertia a motor of the repulsion type should be used. These motors will develop when connected directly to the line at rated voltage about 250 to 350 per cent. full-load starting torque on about 250 to 300 per cent. full-load current. By using a starting rheostat full-load starting torque can be developed with about 125 per cent. full-load current and they can be built to operate satisfactorily in most any size.

Jenkins Graphite Lubricator

To introduce into cylinders of steam units a lubricant in which graphite has been mixed has been a problem, but a lubricator has recently been perfected which will feed any amount desired.

The lubricator is preferably placed away from the cylinder, it being considered better to feed it cold as the graphite might otherwise precipitate. The lubricator will work at 50 deg. F. below zero as well as in an engine room, it is stated. When the lubricator is empty, it automatically stops.

The lubricant used is called "grapho-grease," and is pushed forward in the conduit pipe to and through an atomizing nozzle bent U-shape, as shown. The nozzle points against the direction of the flow of steam. The grease in the gooseneck of the nozzle awaiting ejection becomes heated to the temperature of the steam and readily atomizes.



New Design of Graphite Lubricator

The lubricator consists of a 3½-in. diameter cylinder in which is a plunger and a screw plunger rod. At the top is a ratchet arrangement which is operated from any available moving reciprocating part of the engine. The ratchet turns a worm which transmits its motion to the worm gear, which in turn screws the plunger rod downward, thus forcing a small amount of lubricant through the ¼-in. conduit, and out of the ⅛-in. goose-neck atomizer at each stroke of the engine.

This lubricator, which is made by the Jenkins Graphite Lubricating Co., 709 Gerke Building, Cincinnati, Ohio, is designed to be refilled while in operation by throwing out the ratchet and reversing the movement of the worm gear by turning the crank gear. This brings the plunger out of the cylinder, when the latter can be refilled with grease. The plunger is then screwed down until it comes in contact with the grease, when the ratchet part is thrown into engagement and the feeding of the lubricant is resumed.

The conducting pipe is supplied with valves, one of which is a check, which insures against blow-back when refilling. The moving parts work slowly, and all parts subject to wear are made of case-hardened steel. The thrust against the piston stem is supported by an independent ball race.

⁂

Color Scheme for Piping of Building

Several color schemes have been suggested for the pipes of power plants, but in a large office building, department store or hotel there is a forest of pipes for all sorts of purposes, which call for many colors if each is to have a distinctive hue. The following scheme was devised by Edward E. Ashley, Jr., mechanical engineer with Starrett & Van Vleck, New York, for the new Lord & Taylor building, of which they are the architects:

LORD AND TAYLOR BLDG.

Colors of Paint to be Used on Mechanical Equipment

Vapor or vent	*Naples yellow*
Leaders	*Aurora yellow*
Drinking water waste	*Raw sienna*
Acid waste	*Burnt sienna*
Ejector waste	*Burnt umber*
Soil and house sewer	*Vandyke brown*
Fire line	*Vermilion*
Ammonia	*Violet*
Brine	*Cobalt blue and white*
Cold water	*Cobalt blue*
Drinking water	*Prussian blue*
Drinking water ret.	*Ultramarine*
Hot water	*Emerald green*
Hot water return	*Hooker's green*
Sprinkler main	*Venetian red*
Sprinkler dead riser	*Crimson lake*
High pressure steam	*Deep orange chrome*
Medium pressure steam	*Chrome yellow medium*
Kitchen steam	*Chrome yellow*
Exhaust steam	*Yellow ochre*
Heating	*Olive green*
Return	*Chrome green*
ed lines	*Apple green*
High pressure drips	*Orange chrome pale*
ow pressure drips	*Chrome yellow pale*
low off	*Claret*
Oil pipes	*Terra-cotta*
Tempered air ducts	*Body of duct to match room, light red arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
xhaust ducts	*Body of duct to match room, light brown arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
Toilet exhausts	*Body of duct to match room, medium brown arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
ir inlets or cold air ducts	*Body of duct to match room, light blue arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
ir piping, high	*Light grey*
ir piping, medium	*Medium grey*
ir piping, low	*Dark grey*
Hydraulic pressure	*Bremen blue*
Hydraulic discharge	*Chinese blue*
Machinery	*Brewster green, carmine striping.*

Hoppes V-Notch Meter Recorder and Integrator

Back in 1860 and 1861, Professor Thomson, at Queen's College, Belfast, and at Glasgow University, devoted considerable time in experimenting with a view to checking the value of the coefficient 0.305 of the formula

$$Cu.ft.\ per\ min = H^2\sqrt{H}\times 0.305$$

upon which the flow of liquids over a V-shaped notch weir discharge is based. Professor Thomson's constant has since been carefully tested, and the results show that the constant 0.305 was remarkably accurate for heads ranging from 2 to 7 in. Based on the foregoing formula, several designs of V-notch meters for measuring the flow of liquids have been perfected.

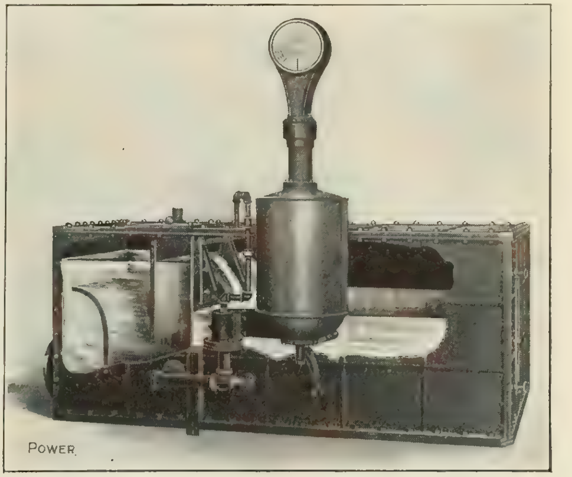


Fig. 1. Sectional View of Tank with Hoppes V-Notch Recorder and Integrator

The recording apparatus in some V-notch recorders is operated by a float arranged in various ways. In one type a float spindle is attached to a float on the surface of the water flowing over the V-notch, and passes up through the bottom of the instrument case. The float is in a float chamber in the compartment back of the weir and is not disturbed by the flow of the water. The float spindle operates the recording apparatus.

New features have been incorporated in the Hoppes V-notch meter, recently developed by the Hoppes Manufacturing Co., Springfield, Ohio. The difference between this apparatus and the English type is that the recording instrument in the latter is operated by a float, while in the Hoppes meter the height of water behind the V-notch is weighed by a vessel so designed that it contains just enough water at each unit of height to pull down a spring in a regular ratio and according to the rate of flow through the notch.

Referring to Fig. 1, it will be noted that the meter consists of a cabinet attached to the tank by a bracket. On the inside of the cabinet there is a vessel *A*, Fig. 3, suspended by a coil spring *B*, and connected to the tank by a flexible metal-hose water connection *C*, and the flexible equalizing connection *D*, at the top. The flexible connection *C* is attached to the tank behind the V-notch so that the water in the vessel *A* will always be in equilibrium with the water above the weir.

The V-notch *E* is shown set at the relative height at which it would be in the tank. The height of the V-notch is 8 in., and the water shown is 6 in. over the weir. The drop in the vessel for a full 8-in. weir is approximately 4 in. and at 6 in. the drop is 2 in., so that the vessel shown in the illustration has approximately 8 in. of water above the upper end of the small curved tube *F*, at the bottom of the vessel, to which the pet-cock is attached.

The vessel *A* is designed to contain just enough water at each unit height, behind the weir, to draw down the spring *B* in exact ratio to the rate of flow which permits the recorder and integrator to be directly attached to it without the use of cams or other motion-changing devices.

The method of adjusting the head to bring the vessel to the proper height is to loosen the two long screws in the head *G*, and raise or lower the head by means of the band *H*, as desired. The height of *A* relative to the V-notch is important, and the best way to adjust it is by allowing the tank and lower connections of the vessel to fill with water until a small amount runs through the V-notch. The water is then allowed to run down until it is at the lowest point in the V-notch, when the pet-cock *J* is opened.

If the instrument is correctly adjusted, the water will drop slowly from the pet-cock, showing that the lowest point in the vessel is on a level with the V-notch. Should no water show at the pet-cock, the band *H* should be turned to the left; should the water flow too freely, the band should be turned to the right until the water nearly ceases to flow, care being taken at each observation to see that the vessel *A* is at rest.

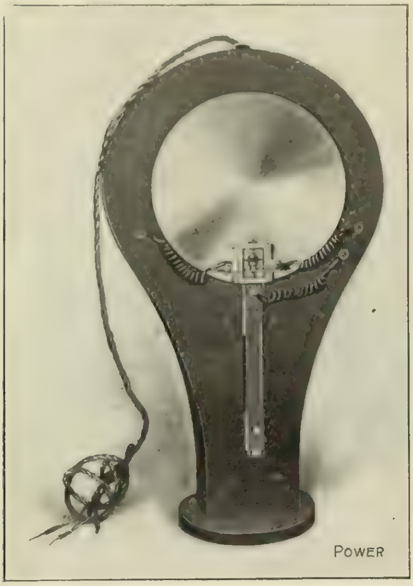
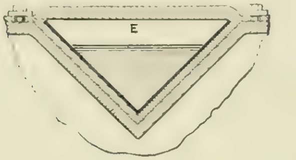


FIG. 2. DISK SIDE OF HEAD, SHOWING PLANIMETER WHEEL



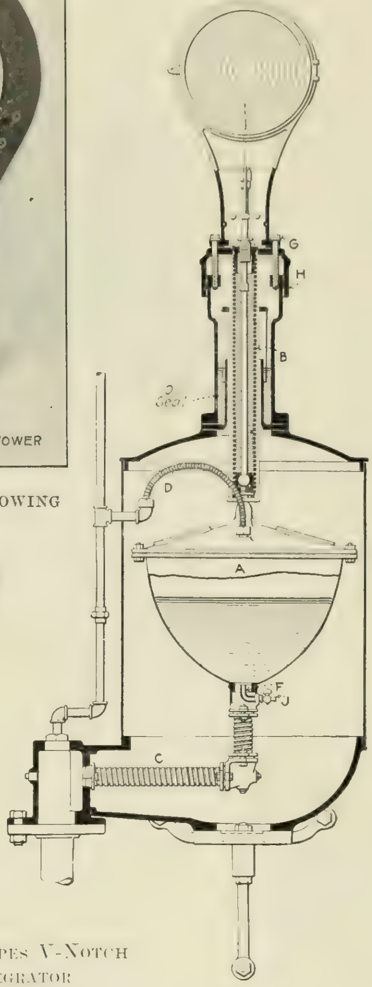


FIG. 3. DETAILS OF HOPPES V-NOTCH RECORDER AND INTEGRATOR

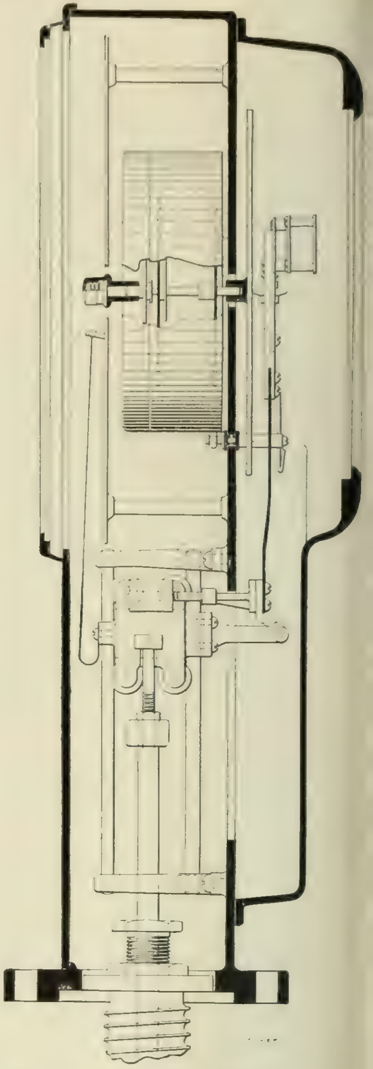


FIG. 4. SIDE ELEVATION OF THE RECORDING INSTRUMENT

After the vessel is adjusted and the screws in the head *G* are tightened, the pen should be brought to the neutral line near the center of the chart by adjusting the screw connecting the top of the rod with the crosshead. Adjusting the pen to the neutral line should bring the planimeter wheel to the center of the dial in the rear, Fig. 4. Comparing this illustration with Fig. 3, it will be seen that Fig. 4 is an enlarged sectional side view of the registering mechanism, or that part of Fig. 3 above *G*.

When regulating the height of the vessel it is also necessary to adjust the brass sleeve through which the rod passes so as to give a clearance of the stops in the rod below and above the sleeve. The apparatus is then ready for service.

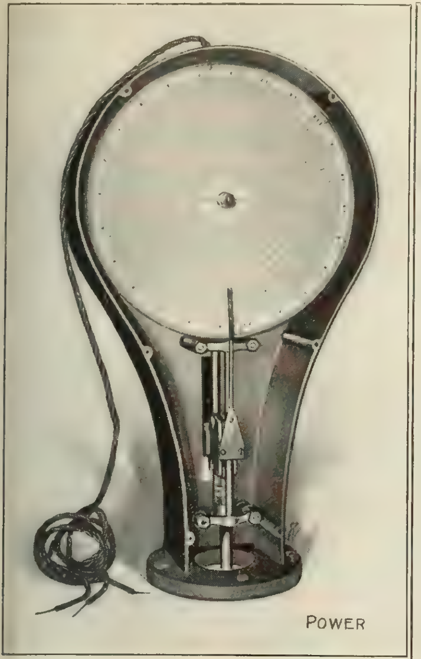


Fig. 5. Chart Side of Recorder Showing Guide and Pen

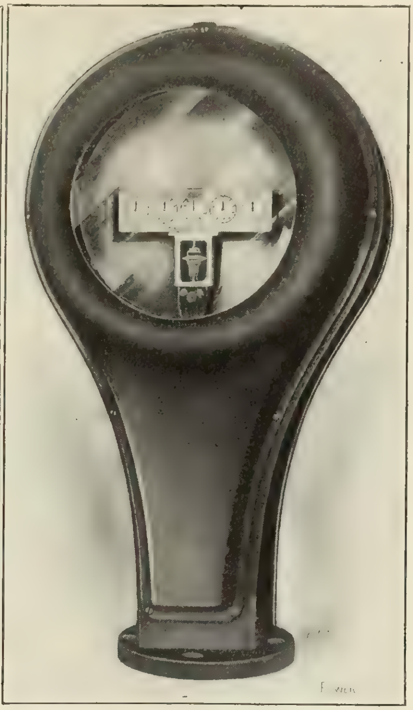


Fig. 6. Mechanical Integrator

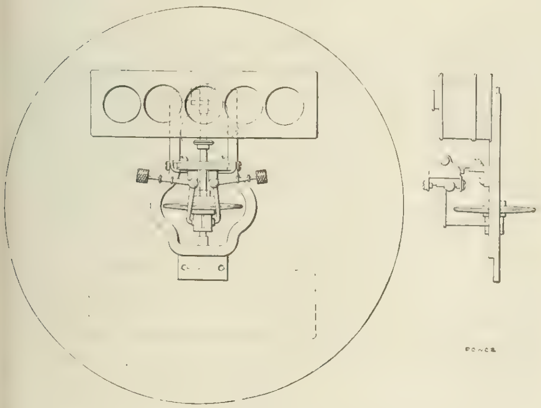


Fig. 7. Details of Integrating Indicator

The recording and integrating apparatus is located in the head on a column supported by the cabinet. In the head is a clock movement which operates a circular chart on one side, making one revolution in 24 hr. On the other side of the head is an aluminum disk making one revolution per hour. These are shown in Figs. 2 and 5.

Just below the head is a vertical guide with a crosshead running between anti-friction bearings and connected to the vessel *A*, as shown in Fig. 3. The pen is attached to the crosshead on one side for making the record on the chart. An arm is carried to the other side which supports a small planimeter wheel on a vertical axis and is revolved by the disk. This feature is shown in Fig. 4. The planimeter wheel moves a train of gears for operating the integrator, Fig. 6, which indicates the amount of water in pounds that has passed the weir for any given period.

When the water is just starting over the weir the planimeter wheel rests at the center of the disk. As the head increases and the vessel *A*, Fig. 3, descends, the planimeter wheel is drawn toward the lower periphery of the disk, and as the disk has a constant motion, a correct record is made of the water passing the weir at any given time.

In cases where the meter is located in an inaccessible place, the planimeter wheel may be provided with a commutator and wire connection carried to an electrically operated integrator, located at any distance. In Fig. 7 are shown details of the integrating device. Fig. 8 is a view of the electric integrator.

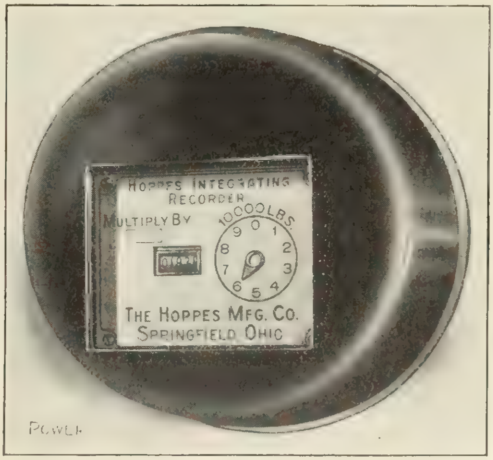


Fig. 8. Electric Integrator Indicator

The circular charts used on the recorder are 12 in. in diameter, which is large enough for the records to be easily read and small enough for them to be filed conveniently. When it is desired, the charts can be measured by the use of a circular planimeter and the record checked against the integrator.

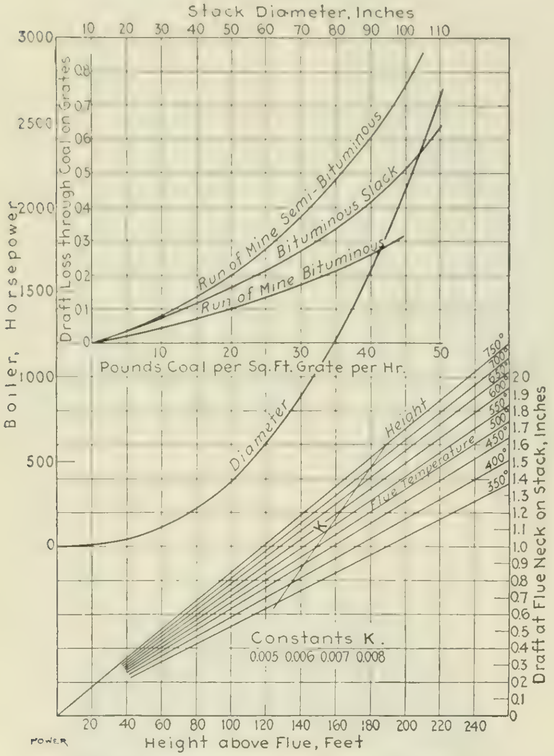
Selection of Stacks and Breechings

By B. S. Nelson

SYNOPSIS—A simple and reliable way of selecting a stack of the proper diameter and height for natural draft, without the need of using long and complicated formulas.

⁂

The standard tables of chimney sizes are convenient, and much used, but it is sometimes puzzling to know just which one of the several sizes of stacks is best to select. By increasing the diameter, the height can be reduced and conversely, but there should be one size which is cheaper to build than the others.



Curves for Selecting Stack Sizes

In plotting the curves shown herein, it was the purpose to try and put the data available in such shape that with the conditions of grate surface, kind of coal, rate of driving and stack temperature known, the most economical stack could be selected without computation. The data in these curves can be found in any good handbook, but it is here arranged in more convenient form.

For a given case, a stack has to carry a definite volume of gases. So long as the stack is high enough to produce a draft sufficient to carry the air necessary for combustion through the coal bed and boiler, it can be made to handle almost any capacity by increasing the cross-section, but a point is soon reached where it is cheaper to use a higher stack of smaller diameter.

The draft a stack produces, and hence its power to carry off gases, is proportional to the height and the stack temperature. Without going into the formulas the draft equals $K \times h$, where h is the height and K is a constant varying with the temperature of the flue gases and naturally increasing with the temperature. The altitude and atmospheric temperature also enter into the constant K, but for all ordinary cases the barometer is taken as 14.7 lb. and the air temperature 60 deg. F. The curves are plotted on this basis.

It has been found by comparing the cost with the height and diameter for various horsepowers, that the cross-section of the cheapest stack is practically in proportion to the boiler horsepower, which means that the diameter of a minimum cost stack is independent of the height. The diameter curve shown is from "Stirling" and gives diameters necessary for various horsepowers. It is based on about 40 sq.in. of area per 100 boiler horsepower, which is large enough to carry 50 per cent. overload. The diameters also take into account the loss of effective area due to the gas clinging to the stack sides.

The force of draft necessarily depends upon the resistances through the furnace, boiler, breeching and stack. The furnace resistance necessarily depends on the kind of coal and the weight burned per hour per square foot of effective grate. The curves give the draft necessary for burning various kinds of coal at various rates of driving the grates. For an average condition, i.e., with bituminous slack coal and a grate ratio of 1 to 55 of boiler-heating surface, and assuming 5 lb. of coal per boiler horsepower, or

$$\frac{55}{10} \times 5 = 27.5 \text{ lb.}$$

of coal per square foot of grate, a furnace draft of 0.24 will be required.

The friction through the boiler naturally varies with the type. For a return-tubular and B. & W. boiler it is about 0.25 in. and for a Stirling boiler about 0.35 in. Through the breeching the friction varies with the cross-sectional area, length and number of turns or elbows. A properly designed breeching has an area at the stack of $1\frac{1}{5}$ times the area of the stack, which figures about 48 sq.in. per 100 boiler horsepower. With such a breeching, the draft loss is about 0.2 in. per 100 ft. of straight flue and 0.1 in. for each right-angle turn, counting where it enters the stack as one turn. In the stack the drop may be taken as one-fifth of the total draft required. For all ordinary cases a loss of 0.1 in. is a safe figure.

Example

Take a concrete example: A battery of four 200-hp. B. & W. boilers with the stack at one end of the battery and 10 ft. behind the boilers; distance from farthest boiler to stack 75 ft. Fuel, bituminous slack; grate surface of each boiler, 44 sq.ft. Coal burned will be about 4 lb. per boiler horsepower per hour, which equals

$$\frac{200}{44} \times 4 = 18.2 \text{ lb.}$$

per square foot of grate surface. Allowing 50 per cent. for overload and dirty grates, a total of 27.3 lb. of coal per square foot of grate will be required.

From curve draft necessary, in.	0.23
Loss through boiler, in.	0.25
Loss in 75-ft. breaching (0.75 × 0.2), in.	0.15
Loss in one elbow, in.	0.10
Loss in stack, in.	0.10
Total draft required, in.	0.83

The stack temperature should not be over 500 deg. F. at rating, and from the 500-deg. curve for 0.83 in. of draft a height of 123 ft. is obtained. It will be seen from the height curves that if the stack temperature goes up to 650 deg., as it would if the boiler was forced, the draft would be 0.96 in., which gives a good margin of draft.

The diameter curve for 800 hp. gives a diameter of 67 in. Hence, the stack required would be 67 in. by 123 ft. The breeching area would be

$$1.2 \times 0.7854\ (67)^2 = 4230\ sq.in.$$

or 29.3 sq.ft. at the stack.

A good proportion for the cross-section of the flue where it enters the stack is to make the width 0.6 times the diameter of the stack. For this case it would be

$$0.6 \times 67 = 40.2\ in.$$

$$\frac{4230}{40.2} = 105.3\ in.\ high$$

The draft through the fire will depend on the maximum overload to be carried and the character of the coal. A free burning coal uses practically all the grate surface, whereas a coal that clinkers badly may cover up a considerable percentage of the grates. For this reason it is well never to figure the furnace draft less than 0.25 in., although 0.23 in. was used in the above example to explain the curves.

Power from Mercury Vapor

Mercury vapor as a medium for the production of power was proposed by W. L. R. Emmet in a recent paper before the Schenectady Section of the A. I. E. E. The proposition contemplates the use of a mercury boiler in series with a steam boiler, the mercury vapor at high temperature to be used in a turbine. The project has, in fact, taken more definite form than a mere proposal, for Mr. Emmet has been carrying on experiments for nearly a year and has just completed a 100-hp. unit.

From a thermodynamic standpoint, mercury is superior to steam as it can utilize much higher temperatures without excessive pressures and thus increase the theoretical efficiency, $\frac{T_1 - T_2}{T_1}$. At atmospheric pressure mercury boils at 677 deg. F. and it condenses in a 28-in. vacuum at 455 deg. F. Moreover, the specific heat of the liquid is 0.0373 and of the gas, at constant pressure, 0.0248, and the latent heat of vaporization varies from 117 B.t.u. at 25 lb. absolute to 121.5 B.t.u. at 29 in. vacuum. These figures, at a glance, account for the higher temperatures of the mercury vapor.

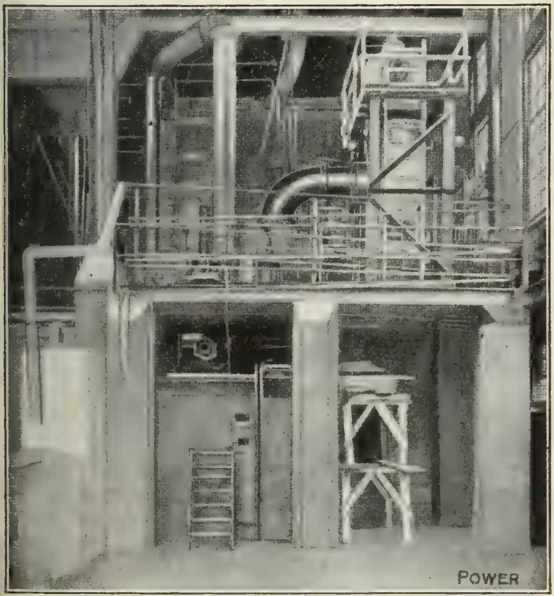


Fig. 1. Experimental Mercury-Vapor Boiler Now in Use

Another characteristic in favor of mercury vapor is its high density, hence relatively small volume compared with steam at the same pressure. This is important in that much shorter blading can be employed in the low-pressure stages of the turbine.

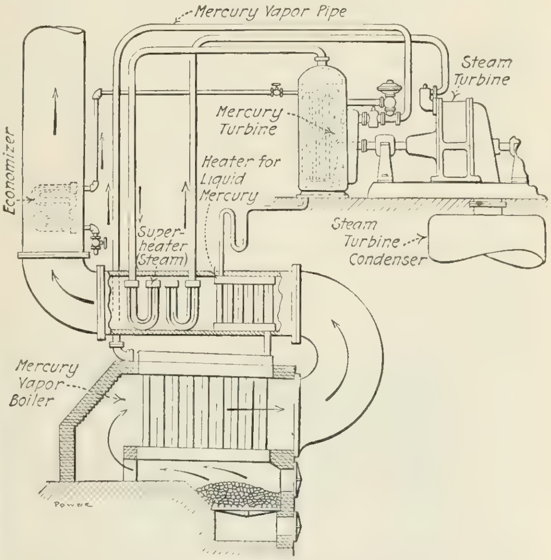


Fig. 2. Section through Mercury-Vapor System

The process as outlined by Mr. Emmet is essentially as follows: Mercury is vaporized in a boiler, having a furnace of the ordinary type, and passes at a pressure slightly above atmospheric to the nozzles of a turbine. From the turbine the vapor passes to a condenser, or more properly speaking, a condensing boiler, where it is condensed on the outer surface of tubes containing water. The heat given up by the mercury vaporizes this water and produces steam to drive other turbines or for other purposes. This steam may be produced at relatively high pressure, for the temperature of the mercury corresponding to a 28-in. vacuum is 457 deg. F.

The condensing boiler is preferably placed at a level above the mercury boiler, so that the condensed mercury will run back into the boiler by gravity without the aid of a pump. Since the mercury vapor is much hotter than the steam, the gases leave the mercury boiler at higher temperatures than normally in a steam boiler. To utilize this excess heat in the gases, it is proposed to convey them first through a heater which raises the returned liquid mercury almost to the boiling point, then to pass them through a superheater which superheats the steam from the condensing boiler, and finally through an economizer which will heat the feed water for the condensing boiler. The outfit is shown diagrammatically in Fig. 2.

Assuming the heat transfer in the mercury boiler as equivalent to that in a steam boiler under like conditions, and a turbine efficiency equal to that of a steam turbine, Mr. Emmet figures a gain of 66 per cent. in delivered power at an additional fuel expenditure of only 15 per cent., as compared with the ordinary steam plant.

Indications are that about $10 worth of mercury would be required per kilowatt of the mercury turbine.

⁂

Portable Air Compressor

A convenient portable air compressor for use about a power plant is made by the Gardner Governor Co., Quincy, Ill. The outfit is built both motor- and gas-engine driven, as illustrated in Figs. 1 and 2.

The compressor cylinders are 2x2½ in., and are mounted vertically. The compressors are self-oiling and air-cooled. In one, a ½-hp., 110- to 220-volt motor, either direct or alternating current, is used; the other unit is belt driven by a 1-hp., vertical, air-cooled gasoline engine. The engine is guaranteed to run for 10 hr. with full load and without overheating.

Each compressor is fitted with a cast-iron receiver to catch the moisture and oil that may be carried over with the air. A cover is provided to protect the machine from dust. The complete outfit is mounted on a truck for portable service.

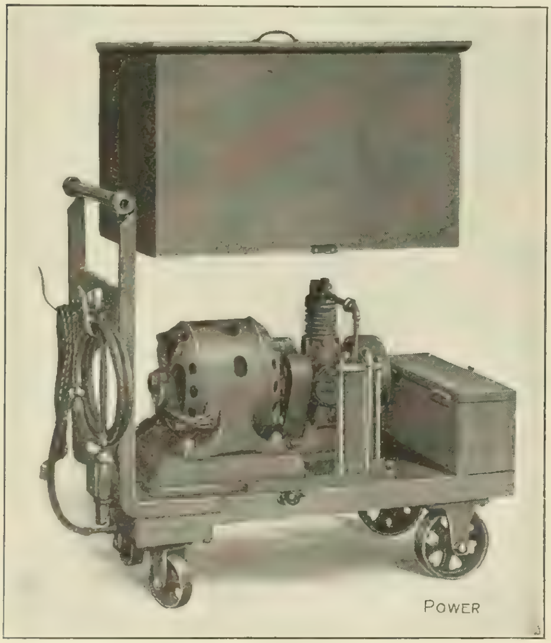


FIG. 1. MOTOR-DRIVEN AIR COMPRESSOR

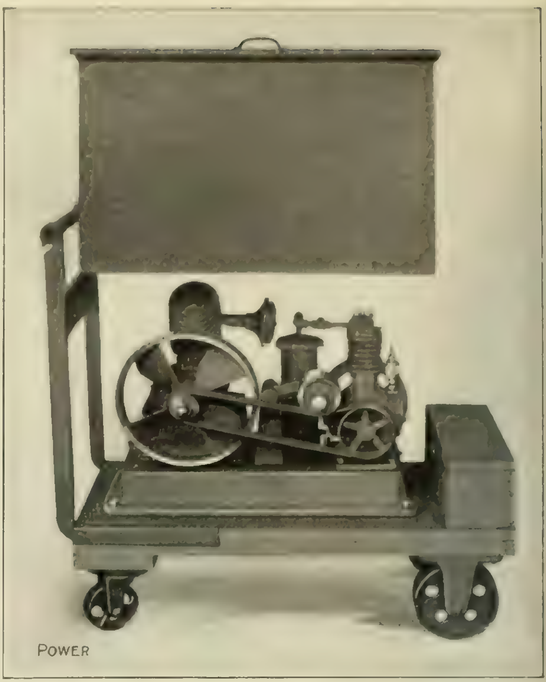


FIG. 2. GAS-ENGINE-DRIVEN AIR COMPRESSOR

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Testing for Ammonia in Brine

Although Nessler's reagent for testing for ammonia in brine or water is widely known, the number of inquiries concerning its use indicates that all who wish to prepare and use it do not know how to do so.

Leaks in coils carrying ammonia and surrounded by brine or water are difficult to detect at first, and usually continue until the brine or water has the odor of ammonia. If one suspects that coils are leaking, a sample of the brine may be drawn into a test tube or other receptacle (glass preferred) and a few drops of Nessler's reagent added. If the brine contains a little ammonia, it will take on a yellow shade; if there is much in the brine, it will turn brown when the reagent is added.

Nessler's reagent may be made as follows: Dissolve 17 grams of mercuric chloride in 300 c.c. (approximately 10.6 oz.) of distilled water. Next dissolve 35 grams of potassium iodide in 100 c.c. (about 3.5 oz.) of distilled water. Add the potassium-iodide solution to the mercuric chloride and stir until a red precipitate is formed. Now add 120 grams of potassium hydrate dissolved in 200 c.c. (about 7 oz.) of water. As the solution will get hot when the potassium is added, it should be allowed to cool before being stirred. When cool, pour in distilled water until there is 1 liter (about 1 qt.) of solution. Next add more mercuric chloride until a permanent precipitate again forms.

The liquid should stand until the precipitate has settled and left the solution clear, after which pour it into a dark-brown or blue glass-stoppered bottle, and keep it in a dark place.

Editorials

Eternal Vigilance

A letter in the correspondence department tells of the improvements made in a plant during the chief engineer's absence. The assistant engineer was not the one responsible, for he had acted under the master mechanic's directions, but he was accused by the chief when he returned of having designs on his position.

The small caliber of a chief engineer who would take this view of the situation is so self-evident as to occasion no comment. He is a man of the stamp that no one cares to call friend. He is one to be pitied, because he is compelled to be constantly associated with himself. But this is not the phase of the incident that suggested this discussion. Rather is it the carelessness of a chief who would let his plant drift along with everything just good enough to escape special criticism, and so leave such an easy opportunity for someone to come along and make a splendid showing of improved conditions.

Had the assistant made the changes of his own volition and with the purpose of drawing favorable attention to himself, he would have been entirely justified under the circumstances. A chief engineer so neglectful would have deserved it. The more becoming thing for this returning chief to have done would have been to resign and take himself off to a new field and there resolve to give no one else a chance to show him up at a disadvantage. He would have merited some respect then for asknowledging his fault. To have stayed on and persisted as he did in the apathetic conduct of his plant was pure presumption, a brazen display of indifference to his own deficiency that, to say the least, was contemptible.

The big lesson of all is not to get into this unenviable position, and the only way to avoid it is to maintain an unrelenting attention to the little things. Let every engineer keep uptodate—no need to say how, for the ways are well known—and then there will be no fear that the subordinate will supplant him. To paraphrase a familiar quotation: "Eternal vigilance is the price of security in one's position."

*

Supplies Bought and Sold

One of the most hopeful signs of the times is the tendency of buyers to buy supplies instead of simply having them sold to them. In other words, the engineers are deciding what is needed, then what maker's product seems best suited to meet the requirements peculiar to their plants. It then becomes a matter of price and delivery, etc., and not who happens first to come in to get the order or in some cases to make the suggestion primarily.

Time was when salesmen walked in and looked the plant over and prescribed such cure-all supplies as they might happen to be exploiting as absolute necessities to the welfare of the plant and happiness of the engineer in charge. Be it said of them that they were often able to advise and suggest wisely by reason of their general information and intimate knowledge of their particular line and what it had actually accomplished elsewhere, facts of which the engineer had no means of knowing. But conditions are changing rapidly, for the reason that broader reading and more and better advertising have given the buyer an insight into the possible usefulness of all standard equipment.

No plant has in it every possible refinement, but no engineer worthy of the name is so obtuse as not to know what his plant lacks far better than a stranger. He should decide for himself beforehand and be able to say that he considers the purchase advisable or inadvisable as the case may be, giving sound reasons. Having abundant engineering literature, and manufacturers' catalogs which form no small part of his necessary reading to keep abreast of the times, it is inexcusable if he is not sufficiently informed to buy that which is best for his plant and employers.

Rummage-sale buying makes rummage plants and nothing can jar on the trained senses more than a plant fitted out elaborately or luxuriously in some particular, and neglected to a like degree in some other. It shows that a salesman has been there, and the buyer, like the old colored mammy, "just done followed off after the band."

*

The College-Bred Engineer

Every year thousands of young men enter our engineering colleges and universities, full of hope and ambition and expecting to emerge full-fledged engineers. How many of these young men know the real meaning of the word "engineer"? How many of them know the real meaning of "education," and have definite ideas of what they are going to get out of their four years in college? The percentage seems to be rather low. They seem to have a blind faith in the college's ability to make engineers of them. They spend the four years studying books and wait until after graduation to discover that what has been done in school is a very small part of what they must do before they can call themselves engineers.

Our colleges are doing a great work and deserve the highest commendation, but too much is demanded of them by many people. Too much faith is placed in their ability to perform miracles. Many a man thinks that an engineering college should be able to take his boy, who is naturally cut out to be a ribbon-counter clerk, and by some mysterious process turn him out at the end of four years a second "Steinmetz." Probably more often the boy enters college laboring under this same delusion.

There is no engineering college in existence, no matter how efficient its staff of instructors, or how well planned its course of studies, that can transform a young man who has had little or no practical experience into a finished engineer.

The primary object of any engineering college is not to produce engineers, but to produce men who can think.

It further furnishes them with a foundation of fundamental engineering principles upon which they may build a superstructure of success out of material gained through the experience of a practical application of these fundamentals. The scope of the college both in time and space is too small and the growth of all branches of engineering is too large to admit of very much practical experience being included in the college course. The training gained in school, however, makes it much easier for the college graduate to acquire practical experience and to make further use of it after it is once acquired.

Many college-bred engineers are also mistaken in thinking that their college education makes them superior to their less fortunate "self-educated" brothers. There are absolutely no grounds for such a belief, for all about us we can see successful men who have received their education in the college of hard knocks by dint of hard work and by sticking to a thing until they have mastered it. Someone has truly said, "all education is self-education, the schools and colleges are simply agencies to make the learning easier."

One of the great advantages that a college education gives a man is that it makes it possible for him to reach the maximum point on the curves of his efficiency and ability at a much earlier age than he otherwise could.

To the young men entering the engineering profession we would say, get a college education if you possibly can, but get an education. It is not only a great advantage but it is becoming more and more essential every year. To the young men entering college we would say, don't expect too much of the college; it is no performer of miracles. Its purpose is to teach you how to work to the best advantage, the real work comes after you get out.

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Power Plant Auxiliaries

Whence came the idea that the economy of power-plant auxiliaries is immaterial, because the exhaust steam from them is utilized in part, if not in whole, in heating the boiler-feed water?

In the ordinary turbine plant about sixty-six per cent. of the heat in the steam is wasted, even though the efficiency of the main unit is high. The average type of noncondensing auxiliary requires forty pounds of steam or more per horsepower, the exhaust steam of which is used in heating feed water.

This is stated another way in the article dealing with the economy in steam-power plants on page 436 of this issue. There it is shown that for every forty pounds of exhaust steam needed for heating feed water, one horsepower of auxiliaries would be required in the ordinary method of heating by exhaust steam from the auxiliary exhausts, or a total of forty thousand pounds of steam in a plant using three hundred thousand pounds of steam in the main units.

If more economical auxiliaries are used, consuming, say thirty-five pounds of steam per brake-horsepower, thirty-five thousand pounds would be available for heating the feed water, but as forty thousand pounds of steam would be required, five thousand pounds of steam would have to be supplied from some source other than the exhaust from the auxiliaries.

It is suggested that this deficit in the necessary steam supply could be bled from the high-pressure stage of the main unit, which would not only heat the feed water to the desired temperature, but would make a saving in the plant operation.

⁂

Some Central Station Statistics

Interesting deductions may be made from the statistics of central stations in this country for 1912, as given out by the Census Bureau. As might be expected, New York leads with a total kilowatt-hour output of approximately 2,175,000,000. California is a close second with 1,747,000,000, and Illinois, Pennsylvania, Michigan, Ohio and Massachusetts follow in the order named.

Based upon the population, however, we find Montana leading with a yearly output of 1000 kilowatt-hours per person. California is next with 735 kilowatt-hours per person; Idaho has 350; New York and Illinois 239 and 204, respectively; Massachusetts, 115; Ohio, 84, and Pennsylvania only 77.

California, with a total output four-fifths that of New York, has three times the output per person, yet the average price per kilowatt-hour is only about six-tenths that in New York. Again, Illinois, with two and one-half times the population of California, sold only two-thirds the amount of power, the average price per kilowatt-hour being nearly double.

The figures refer only to those plants which sell their product and hence do not include private installations. During the past year a number of large hydroelectric plants were opened in the South and West. To what extent they will alter the general character of the statistics is hard to tell. The report for 1913 is not ready but the influence of these plants probably will not show to a marked degree until the figures for the present year have been compiled.

⁂

Candid Chats

A candid chat; a plain heart to heart talk with someone on a subject of mutual interest; who does not enjoy it?

And when such a chat relates to your work, when it explains what you want to know, or deals with what you ought to think about, then it recalls the talks you used to have with the old fellow who first showed you how to get up steam and clean the fire without putting it out.

In this issue the first of a number of forewords, in the nature of simple, frank chats on matters of practical interest appears. The subjects will not be confined to any one class or theme. They will deal with the various phases of power-plant engineering in the same straightforward, simple way as did the old fellow whose memory you cherish.

⁂

George Bevins, a coal dealer of Terre Haute, is working to put himself and the other members of his ilk out of a job. He has a perpetual-motion machine. A motor drives a dynamo, the dynamo charges a storage battery, the storage battery runs the motor, the motor the dynamo, and so the circuit is complete, only that somehow in the process some twenty per cent. more power is available than first left the storage battery. The public prints of Terre Haute assert that he has been working on this "scheme" for fifteen years. The word "scheme" is well used. Mr. Bevins is fooling the public, himself, or both.

Correspondence

Steam Chart with Hand Firing

The chart shown herewith indicates the regularity of the steam pressure carried on the boilers of our plant. Similar charts have been shown to people who have never seen the plant and they have invariably said that we have either stokers or else automatic regulation, blowers, etc., were used.

We have water-tube boilers of 314-hp. capacity, hand fired and the usual electric station load. The boiler pressure is 150 lb. and the feed water averages 208 deg. F. Northern Colorado slack coal, classed by the Government as a sub-bituminous, is used.

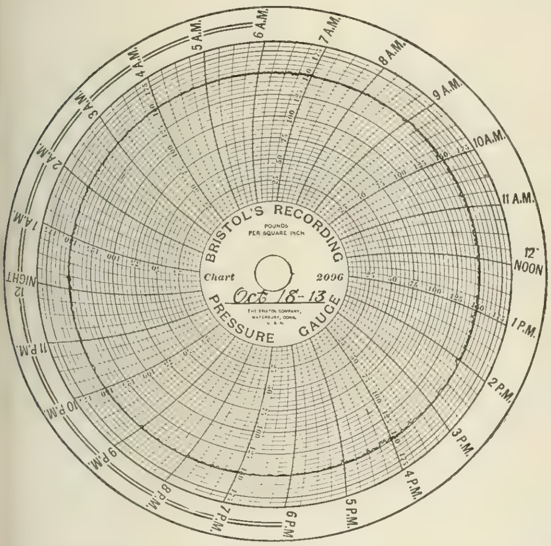


Chart Obtained with Hand-Fired Furnace

A. E. Anderson.

Laramie, Wyo.

⁂

While the Chief Was Away

The chief engineer of a certain plant was taken sick. According to the chief, the assistant engineer knew nothing. The plant came under the jurisdiction of the master mechanic, who looked after things while the chief was out, and he had the assistant make changes that the chief could have made.

For instance, a telltale was put in the boiler room, so that the firemen could tell how much the damper was opened or closed. The damper did not work right, so the assistant went into the flue, and found that when the damper regulator weight in the engine room was up, indicating that the damper was closed, it was open 18 in., although it was made to close to within 2 in.

A different method of firing was tried, which not only saved the door lining, but in a nine weeks' run, with the same load conditions as obtained when the chief was on the job, 97 tons of coal, at $4.50 per ton, were saved. A number of other changes were made all for the betterment of the plant.

When the chief came back he, of course, learned about the changes which had been made and after looking over the log and coal reports and noting the increased economy during his absence, he accused the assistant of trying to get his job. If the chief had been onto his job there would have been no such saving made in the coal consumption, nor the necessity of making the changes.

One would suppose that when the chief got back he would have been pleased and would have continued the good work, but from all appearances he is traveling in the same old rut.

L. J. Olliver.

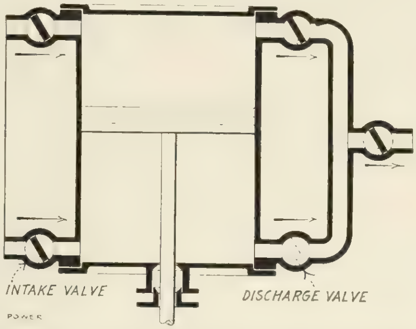
New Bedford, Mass.

⁂

Air Pump Behaves Badly

We have a locomotive type air pump used in connection with the sprinkler system and this pump has lately been acting badly. The strokes were irregular and the gages in the discharge line showed considerable fluctation in pressure. It had been detected that in starting this pump the lower intake valve would admit air only at the beginning of the upward stroke and would close entirely after the gage in the discharge line showed 20 lb. The air end of the pump was examined and the discharge check in the lower end found entirely gone. It had broken into several small pieces and fallen into the clearance space of the cylinder.

This sketch is to simplify the air end of the pump and to show also that there is no check in the lower discharge end.



Section of Air Pump Showing Valves

I offer the following as to the cause of the peculiar action of the lower intake valve.

The lower intake valve admits air until a certain pressure is obtained in the discharge line. The clearance volume is very small and as the piston begins to ascend, the air that has filled the clearance space expands below at the pressure of the atmosphere. There is then a slight admission of air through the intake valve. This admission continues until the air above the piston is compressed enough to close the lower intake valve. When the piston descends, the air taken into the cylinder at the lower end and which came in through the lower intake valve and the upper end of cylinder is discharged (neglecting the amount left in the clearance space) through the discharge check in the pipe line.

This operation continues until the air left in the clearance space has sufficient pressure after expanding to hold the intake valve closed at the beginning of the stroke. By the clearance space I mean the volume up to the check shown in the discharge line.

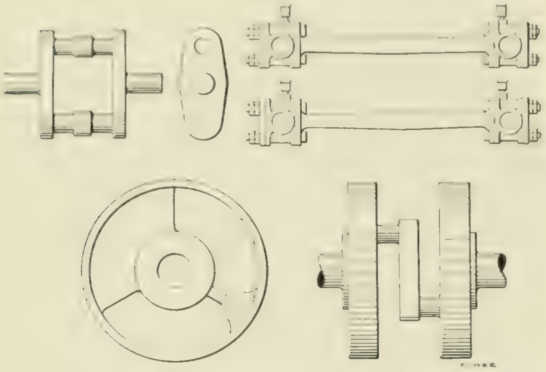
J. W. Dickson.

Memphis, Tenn.

⁂

Williams Connecting-Rod System

In reference to the article in Power, Feb. 10, about the Williams connecting-rod system, I should like to know how the double rods can cross and then uncross and cross again in one revolution, which from a mechanical standpoint is impossible.



The Williams Connecting-Rod System

D. Falk.

Athenia, N. J.

[The two rods are not, of course, in the same vertical plane. The accompanying sketch, also reproduced from *The Engineer,* will make it plain.—Editor.]

⁂

Filing Catalogs

How many of us ever give a thought to the cost of the catalogs we receive? During the last 10 years I have received a number of catalogs, some of great value to me, and have kept them, hoping that some day I could file them away systematically. I installed a plant recently, and as that brought a lot of new catalogs to my desk, it was a case of do something at once. While in town one day, I bought a loose-leaf book that I thought I might make use of for filing catalogs; it is the best I have seen.

Taking the catalog, I cut out all price lists and sectional cuts or views that I might find useful later on, then on one side of a sheet of 9x12 paper (the size of my loose-leaf book), I paste the cuts. On the back of the sheet I paste the price lists and write in whatever I believe will be of value. If I happen to know any faults, or have heard of anything objectionable to the device, I note it down, doing the same with its commendable features.

I do not save testimonials, or anything that does not deal with the subjects in hand, but I do make a note of where I can see that special device in use. I have gone through over 80 catalogs and have at present a book not $^3/_4$ of an inch thick.

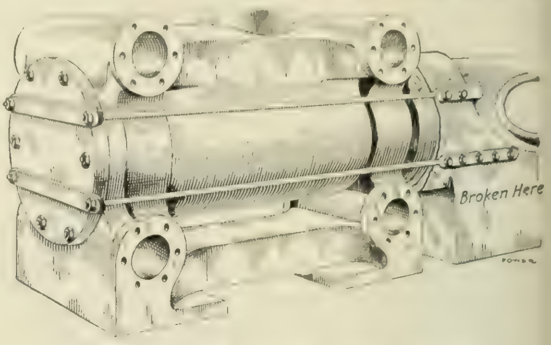
Arthur D. Palmer.

Dorchester, Mass.

⁂

Cracked Cylinder Repaired

The high-pressure cylinder of one of the heavy-duty, cross-compound Corliss engines, direct connected to an alternating current, 600-volt, 480-ampere, three-phase generator, broke between the bedplate and the steam cylinder, as shown by the crack line in the illustration.



The Engine Repaired; Note Crack

It was decided to make a weld with the oxy-acetylene process. This was done, but after a half-days run the cylinder broke again in the same place. Then the operating engineer suggested making the temporary repair shown. Four heavy 3-in. bars, one end of each threaded enough to receive two 3-in. nuts were used; the other ends were flattened and drilled to receive 1-in. bolts and then bolted to the frame. The end pieces were then put on and the broken parts drawn together with the 3-in. nuts. The job is good and the engine is running in parallel with the other units and is doing its work satisfactorily.

J. G. Koppel.

Montreal, Can.

⁂

Care of Boilers

It may interest readers to know how our boilers are cared for.

Our plant of 300 boiler horsepower contains two water-tube boilers, one of which is used about 11 hr. daily. Both are about 19 years old. The boilers were built for a working pressure of 120 lb. per sq.in., but have never had over 100 lb., and in all these years no reduction of pressure has been ordered either by the insurance inspectors or the police department.

The following is a brief outline of our method of caring for the boilers:

Each boiler is used for one month and then cut out of service and given a complete cleaning inside and out.

The outsides of the tubes are cleaned off with compressed air under a pressure of 60 lb., which does the work satisfactorily.

Several caps are removed from both the front and rear headers and a portable light passed through for the purpose of finding out in what condition the tubes are internally. All tubes are cleaned once a year with a water turbine. No compound has ever been used in these boilers. All makeup water used is passed through a filter before it is pumped into and through the heater. The drums of these boilers are given a coating of graphite every two months; about 1 lb. being used for this purpose. The boilers have never been blown down while under the working pressure.

During all the years these boilers have been in use only 15 tubes have been replaced. There are 72 four-inch tubes in each boiler. With this care continued we expect to get a number of years of useful service from these units before they are consigned to the scrap pile.

H. H. Burley.

Brooklyn, N. Y.

A Lead-Pouring Kink

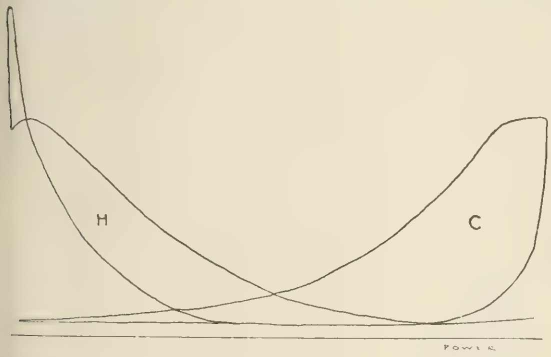
Many engineers have had their patience tried pouring lead around a damp or wet joint on account of the lead spattering or blowing out from the effects of steam generated by the heat of the lead. The trouble may be prevented by putting a piece of resin the size of a walnut into the ladle and allowing it to melt before pouring. It works equally well in babbitting journal boxes, etc., if damp or wet.

Paul Nordstrom.

Hadley, Alaska.

Cause of Flickering Lights

A 14x36-in. engine running at 80 r.p.m. supplies power for driving machinery in a certain shop, including a belt-driven dynamo. The lights supplied from this dynamo flickered every time the flywheel completed a revolution.



Diagrams Showing High Compression on Head End

The voltmeter seldom vibrated less than 10 volts, and frequently showed variations of 30 volts. This defect was ascribed to a low-speed, long-stroke engine, and the use of numerous belts throughout the shop. The significant fact that the lights flickered once for each revolution of the flywheel, instead of every time that the crank passed a center, was overlooked.

When an indicator was applied to the engine, the diagrams shown were obtained. The crank-end diagram shows normal conditions, but the head end indicated excessive compression, as it is 25 lb. above the admission line and exceeded the boiler pressure by about 20 lb. This caused the speed to be reduced for an instant every time the crank approachd the inside center, and flickering lights were the natural result.

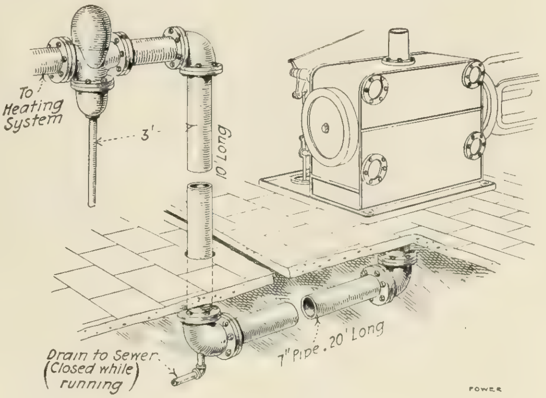
This engine is fitted with double-beat, poppet valves operated by cams. After the exhaust cam on the head end was moved backward for about 1/8 in., another pair of diagrams was taken which showed both ends of the cylinder as receiving and exhausting steam in nearly the same way. Now when there is a full load on the other machinery, the voltmeter sometimes vibrates five volts, but under average conditions it is only two and with a light load in the shop, it is practically constant, thus showing great improvement in the lighting service.

W. H. Wakeman.

New Haven, Conn.

Where Should the Oil Separator Be Located?

There appears to be a lot of oil passing the separator shown in the illustration. A rival salesman recently claimed that no separator so located would work satisfactorily. He said it should be close to the engine in order to get the steam as hot and as free from water as possible. So placed, he would guarantee his apparatus to take out 95 per cent. of the oil.



Present Location

The separator is well drained and the baffle-plates are not cracked. The drain at the elbow below the floor is always closed while the engine is running, and is open at all other times.

I would be pleased to have suggestions from other readers.

G. S. Sprague.

Exeter, Neb.

Separator Glasses

Breakage of steam-separator glasses is one of the engineer's troubles that is hard to remedy because they fail under so widely differing circumstances, that the cause is hard to determine. For example, on a 10-in. receiver separator, in a horizontal line carrying 145 lb. pressure and located in a cold, drafty place about 15 ft. away from the engine and drained to a trap, the glass, which was 20 in. long, would last from six to eight months. Another, glass on a vertical separator at the throttle, in a warm engine room, would last from four to six months. While in another plant carrying 100 lb. pressure, having four separators, the glasses would only last a few days or hours. These separators were vertical and connected directly to the throttles and were well drained. All gages were connected in the usual manner. New glasses were put in for appearance, but the connecting valves were left closed, and the drips open. A new man seeing a slight vapor escaping from the drip cocks closed them, and the condensation filled the glasses and in about 15 hr., one exploded with a loud report. · Another engine was put in service and ran about 2 hr. when that glass exploded.

One writer recently stated that in his opinion the principal cause of breakage is the flow of steam through the glass. This, I believe, is frequently true, although it does not hold good in these two cases. Possibly if the valves were opened only enough to indicate water, if any, it would reduce the circulation.

A gage-glass will last much longer on a horizontal than on a vertical separator, probably on account of the action of the steam shunting through the glass. Frequently the top of the glass on boilers will become worn down to not over $\frac{1}{32}$ in. thick, due to the action of the steam passing through it as the water line rises and falls while the part below the water level remains good.

A 6-in. vertical separator was bought from a prominent firm some time ago, which had lugs cast on the side, but it had not been tapped, and the gage was not sent with the separator. The manufacturers were written to in regard to the matter, and replied that, although cast with lugs for the gage connections, the gage was not included unless especially ordered because it was not absolutely necessary. They stated that engineers found it difficult to keep glasses in place and suggested the use of a try-cock instead. The glass gage was put on, however, but it did not hold.

I have at present three horizontal separators on low-pressure lines, on which the glasses give no trouble.

J. C. Hawkins.

Hyattsville, Md.

⁂

Flywheel Repair

Recently, while shut down at noon, I found upon inspecting the 18-ft. engine flywheel, having a grooved rim and carrying 15 strands of 2-in. Manila rope, two cracks extending across the center rib and about 8 in. on each side of the rib, making cracks about 16 in. long.

We patched it by placing a steel plate ¾ in. thick, 13 in. wide and 4 ft. long on each side of the rib over each break and plates of the same size on the opposite side of the wheel for counterweights.

Then stay rods fitted with turnbuckles were run from each rim joint up to the hub to take the strain. The wheel ran in this way for two months when it was replaced with a new one.

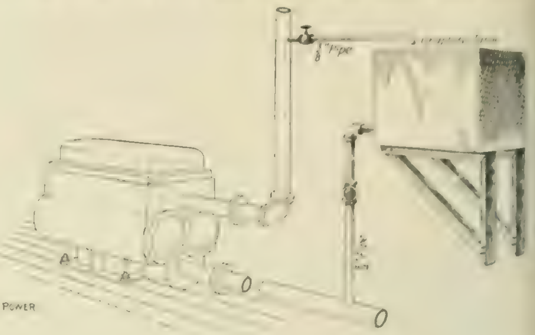
L. E. Chapman.

Wauna, Ore.

Graphite in Boilers

The following has been our experience with graphite covering a period of two years.

We have water-tube boilers of about 500 hp. each. The conditions of service are such that we can give them a thorough cleaning only once a year, but during this time they are taken off the line, emptied and refilled with fresh water once in six weeks. Trouble was had with a hard scale about like portland cement until we used graphite.



Tank and Connections

The graphite is fed by mixing with water in a tank connected to the suction of the feed pump, as shown in the sketch. The first few months we saw no good results, but when we cleaned the economizer we found that most of the graphite was stopping there. In the meantime the boilers were scaling badly and several tubes were burned and bagged so that they had to be removed. After this experience we bypassed the economizer and fed the graphite as directly as possible into the boilers. We do not lose much heat by doing this, because it only takes about half an hour twice a day, of 24 hr., to put the graphite into the boilers. We then cleaned thoroughly with a turbine cutter and replaced all the burned tubes.

At the end of the second year we could brush all the sediment from the drums with a steel brush, and could put the cleaner through the tubes in about three-fourths of the time it had taken the previous year and did not have a single burned tube to replace, although the load had increased about 10 per cent. We saved on the coal, repairs and cleaning.

We have learned not to expect graphite to take off old scale, but to clean the boilers thoroughly and not to let them go for long periods without washing out.

Roscoe Williams.

Brookline, Mass.

⁂

Scale in the Blowoff Valve

The letter from E. O. Hamil, on page 901, Dec. 23, reminds me of what happened at a plant where I was employed as "trouble man" some years ago.

When the engineer opened the blowoff, a 2½-in. asbestos plug cock, to blow down a couple of inches of water he found he could not close it again, because a piece of scale was wedged into it. He quickly drew the fire to avoid burning the boiler, but as soon as the blowoff was again put in order, the superintendent gave orders to fill the boiler at once and steam up, which was done under protest. The boiler, a return-tubular, had diagonal braces extending from the front head to the plate over the fire, and in a few days a leak developed around the rivets of these braces. Upon examination it was found that the plate was slightly cracked at this point, no doubt, caused by unequal contraction when cold water was run in. Two patches 8 in. square had to be put on and the diagonal braces removed and two 1½-in. through stays substituted to make the boiler serviceable.

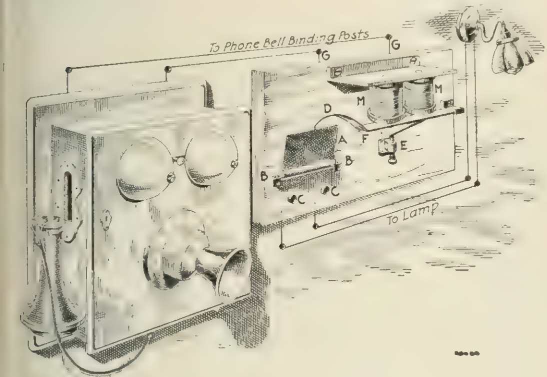
JAMES E. NOBLE.

Toronto, Ont., Can.

A Telephone-Booth Light

Our telephone is located in a dark place. Not wishing to leave the lamp burning continuously, I put on an automatic switch made from parts of an electric bell, which not only lights the telephone booth, but the lighted lamp indicates calls when the place is too noisy to hear the bell.

The magnets, adjusting screw and the vibrator were taken from an old bell. A piece of sheet copper *A* is hinged at *BB;* a small notch at *D* holds the copper plate 1 in a position nearly upright; lines *GG* are the connections from the binding posts of the telephone to the solenoids; *CC* show the fixed terminals for the lamp circuit.



AUTOMATIC SWITCH

When the telephone bell rings, part of the ringing current entering the coils *MM* causes the vibrator *F* to release *A*, which swings down by its own weight, closing the lamp circuit at *C*. When through with the phone, I lift *A* and hook it in the notch at *D* and it is ready for the next call.

E. J. QUINN.

Bellingham, Wash.

Why the CO_2 Readings Were Low

The writer once had an experience that brought to his nind very forcibly the value of flue-gas analysis. We vere remodeling the boiler room; installing stokers and ouilding a tunnel under the boilers for the removal of ishes. There were ten boilers in five batteries. We worked n one battery at a time, building the tunnel walls of concrete. The rear wall was carried up from the stoker loor line with firebrick to form the bridge-wall. Built nto the tunnel wall at the rear and suspended from the stoker floor at the front were the ash pockets. The form umber used for the back of the concrete wall was left in place, the ends projecting beyond the finished wall so as to enable us to continue the construction down the line as the excavation progressed.

When the first boiler was under pressure and preliminary to a test, we took a sample of the flue gases at the damper, the analysis showing 2.5 per cent. of CO_2. Another sample gave 2 per cent.; another 3 per cent. An examination of the setting disclosed no leaks other than a few very small ones that were located with the flame of a candle.

Recharging the Orsat with fresh solutions we tried again and got the same results—2 to 3 per cent. of CO_2. About this time the "glooms" were in the ascendancy. There was an immense air leak—but where?

We were preparing to take samples at the different passes of the boiler with a view of locating the leak by a process of elimination, when the boiler-room foreman reported that the boards left in place back of the concrete wall in the ash tunnel were burning.

Going into the tunnel we found that the boards at one end of the ash pocket had burned out, leaving a hole about a foot wide and five feet high through which a great volume of air was rushing up behind the bridge-wall.

After bricking up the "leak," we took a sample of the gases, which gave 11.5 per cent. of CO_2.

C. O. SANDSTROM.

Kansas City, Mo.

Putting On Long Heavy Belts

Our belt man had to put a new driving belt on an engine, and the belt was heavy and very long. The way he did it may be new to others as it was to me.

He first got one end of the belt ready for the splice. The roll of new belt was placed on the old belt and bolted. The engine, having a reversing valve, was turned over slowly, the belt winding over the pulleys inside the old belt. The clamps were then put on, the rods put in place, and the belt tightened. The old belt was then cut loose, and the new belt was on without the usual hard work. The top part of the belt which is the most difficult to get tight was as tight as the old belt, and the clamps were put on in the correct place for splicing.

M. G. FLETT.

Amherst, N. S., Can.

Lubricating Trouble

The low-pressure cylinder, 50 in. in diameter, of a 1500-hp. cross-compound Corliss engine gave considerable trouble. Pumping in oil would not stop the periodical groaning.

Raising the receiver pressure would help more than the oil, and with a light load the groaning was much worse than with a heavy load. I had the head and the follower plate removed, so that I might see the packing rings. These were found worn to a sharp edge so that they scraped the oil off the walls of the cylinder as well as scored the cylinder walls very slightly. The rings were beveled off at the edges and no trouble has since been experienced in lubricating with a very reasonable amount of oil.

M. W. EASTMAN.

Cambridge, Mass.

Inquiries of General Interest

Care of Fusible Plugs—What care should be given fusible plugs in a boiler?

T. E.

They should be scraped clean on both the water and fire sides whenever the boiler is cleaned.

Exhaust Steam Injector—What is an exhaust steam injector?

C. F.

A boiler feeder which utilizes exhaust steam for warming boiler-feed water and forcing it into a boiler.

Diversity Factor—In central-station operation what is meant by the term "diversity factor"?

E. B.

Diversity factor is the ratio of the sum of the individual maximum demands to the maximum demand on the system as a whole, taken at the point of supply.

Lifting Capacity of Submerged Pump—What advantage, if any, has a submerged piston pump over an unsubmerged piston pump?

D. J.

When a pump is submerged there is less air leakage and consequently a lower percentage of pump slippage.

Advantage of Piston Rod Packing Over Plunger Packing—In lifting by suction what advantages have pumps with piston rods over plunger pumps?

G. E.

In pumps of ordinary design piston-rod packings present less joint surface to be kept tight against air leakage in proportion to pump displacement than plunger packings.

To Stop Foaming of a Boiler—What is the best way to stop the foaming of a boiler?

E. P.

Foaming will usually be stopped by checking the outflow of steam. When caused by dirty water generally it will be cured by blowing down and feeding the boiler and holding the water line at a lower level and checking the fire.

Percentage of Moisture at Different Pressures—Does steam generated at a high pressure contain more moisture than if generated at a lower pressure?

D. W.

Steam generated at one pressure may contain as high a percentage of moisture as when generated at any other pressure, but other conditions being equal, the percentage is often increased with increase in rate of evaporation.

Mud Carried Over to Cylinder of Engine—How can mud be carried over from a boiler through a separator into an engine cylinder?

J. W. P.

Material like finely divided clay, when contained in boiler-feed water, may be held in suspension and discharged along with water which has become entrained with the steam, and may remain in water which has escaped removal by the separator.

Cutting in a Boiler—How should a boiler be cut into a steam main?

J. C. S.

Before opening the boiler stop valve or a header valve, care should be taken that there is no water in the piping between those valves. If the boiler is to be cut in with other boilers it should be under the same pressure as the main with which it is to be connected and the valves should be opened very slowly.

Capacity of Boiler-Feed Pump—What should be the capacity of a boiler-feed pump as compared with the rated evaporative capacity of a boiler?

G. C.

As most boilers may be driven to twice their rated capacities and there should be an additional allowance of pump capacity for feeding water to a boiler when the water level has become low, it is well to provide boiler-feed pump capacity of about $2\frac{1}{2}$ times the rated boiler evaporative capacity.

Intensity of Illumination at Different Distances—If an object is 20 ft. from an electric lamp, what will be the relative intensity of direct illumination from the lamp if the object is removed to a distance of 60 ft. from the lamp?

C. B.

The intensity of direct illumination received from a light varies inversely as the square of the distance, hence by removing the object from a distance of 20 ft. to a distance of 60 ft. the intensity of direct illumination received would b

$$\frac{20 \times 20}{60 \times 60} \text{ or } \frac{1}{9} \text{ as much}$$

Equivalent Resistance of Valves and Elbows—In ordinary steam lines, what lengths of straight pipe should be taken as offering the same resistances to flow as globe valves and right-angled elbows?

T. E.

The lengths offering equivalent resistances to flow would depend on the form and proportions of the valves and elbows, but for all practical purposes it is sufficiently accurate to allow that each globe valve offers resistance equal to a straight pipe of corresponding size, having a length of 60 times its diameter and that each elbow offers a resistance equal to a pipe of corresponding size having a length of 40 times its diameter.

Passage of Heat through Pressure Reducing Valve—What becomes of the heat in steam at 100 lb. pressure when discharged through a reducing valve to a heating system with a pressure of 5 lb. per sq.in.?

J. G.

Excepting the heat lost by radiation in passing through the reducing valve, each pound of steam when discharged at the reduced pressure retains the same number of heat units as it had originally. If its first condition was dry saturated at 100 lb. gage pressure, then when reduced to 5 lb. gage pressure without loss from radiation it would be superheated about 70 deg. F. above the temperature of dry saturated steam at the latter pressure.

Packing Joints of Through Stay-Bolts—What is a good way to make a tight joint where a staybolt passes through the head of a return-tubular boiler with a check nut on the inside and a draft nut on the outside of the boiler head?

C. L. M.

The joint should be packed around the bolt against the inside of the boiler head, and the bearing side of the check nut should be hollowed out so that by setting the check nut the packing will be forced against the boiler head and also cramped around the stay-bolt. For use with such a hollow-sided check nut, a tight and durable packing ring can be built up by winding soft copper wire around the stay-bolt.

Value of French Horsepower—What are the relative values of the French and English horsepowers?

J. V. S.

The French horsepower or "cheval vapeur" represents 75 kilogram-meters per second, and as one kilogram equals 2.20462 lb. and one meter equals 3.28083 ft., a kilogram-meter is equal to 2.20462 lb. × 3.28083 = 7.233 ft.-lb., and the French horsepower is equal to 75 × 7.233 ft.-lb. = 542.475 ft.-lb. per second, or somewhat less than the English horsepower, which is equal to 550 ft.-lb. per second. Hence one cheval vapeur is equal to

$$\frac{542.475}{550} \text{ or } 0.986318 \text{ English horsepower}$$

and one English horsepower is equal to

$$\frac{550}{542.475} \text{ or } 1.01387 \text{ cheval vapeur}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--II

LAST LESSON'S ANSWERS

1. Mechanics.

2. Force is that which produces, or tends to produce, motion or change of motion of bodies; it manifests itself by tension or compression, and attraction or repulsion.

3. In the strength of the cylinder walls and head, and by the resistance offered by the piston.

4. The component of a force is the effect of that force in any given direction.

5. Gravity is the force by which all bodies are attracted to the earth; the weight of a body is the measure of the force exerted by gravity on that body.

RESULTANTS OF FORCE

Any single force which produces the same effect on a body as the combined action of two or more forces is called the *resultant* of those forces. Take, for example, two men pulling on a vertical hoist. Assume each man exerts a pull of 50 lb. Their combined effort is 100 lb. A single pull of 100 lb. would then have the same effect as the combined pulls of the two men. In all cases where the forces are parallel and in the same direction the resultant is easily found by adding together the single forces. When the forces make an angle with each other the process of finding the resultant force is not so simple.

The resultant of a system of forces can be found either *graphically* or *algebraically*. The meaning of resultant force may be made very obvious by an easily performed experiment. Secure two small pulleys, a few pieces of stout cord and several small weights and arrange the apparatus, as shown in Fig. 6. Suppose, for example, the weight at the point *A* is 5 lb., at point *B* 3 lb., and at the point *C* 6 lb. Place a heavy piece of cardboard back of he cords and draw a line parallel to the line *CF* and make it proportional to the weight of 5 lb., according o some assumed scale; in like manner draw another line parallel to the cord *CB* and make it proportional to 3 b. to the same scale. Construct the parallelogram *FDEC* by drawing *DE* parallel to *CF* and *DF* parallel to *CB*. Measure the line *CD* and, if the experiment has been carefully performed, it will be found that the line *CD* will measure 6 lb. to the given scale, and it will further be found that the line *CD* is vertical. Therefore if the weights W_1 and W_3 were replaced by a single vertical force acting upward at the point *C* and equal to 6 lb., this force would keep the weight of 6 lb. from falling.

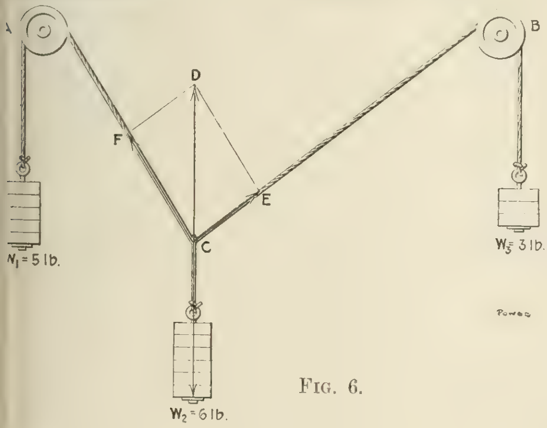


FIG. 6.

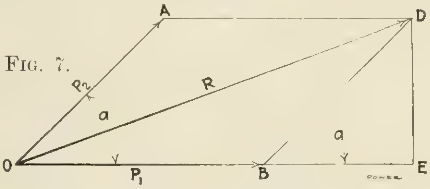


FIG. 7.

It is to be noted that the resultant force is acting upward. The force of 6 lb. acting downward is called the *equilibriant* or the force producing a state of rest.

By varying the weights and changing the lengths of the cords (so as to secure different angles) the student can find the resultant for many other combinations, and he will always find it to be represented by the diagonal of the parallelogram formed by the two forces. From these simple experiments the following law can be stated:

If two forces acting at a point on a given body be represented in magnitude and direction by the adjacent sides of a parallelogram, the resultant of these two forces will be represented in magnitude and direction by the diagonal of the parallelogram passing through this point.

Another truth demonstrated by the above experiment is that the resultant force lies in the same plane with the forces to which it is equivalent. To find the resultant force by a graphical method requires great care in the drawing of all lines and angles and even then a certain degree of error is apt to creep in. For this reason many prefer finding the resultant force by a formula.

In Fig. 7 assume two forces P_1 and P_2 acting at the point *O* and making an angle of *a* degrees with each other. Construct the parallelogram *OADBO* and, from what has preceded, it must be evident that the diagonal *OD* is the desired resultant. What will be the value of *R* in terms of P_1, P_2 and the angle *a?* From the point *D* drop the perpendicular *DE* to the line *OB* (extended to *E*). There will then be formed the right-angled triangle *ODEO*, and from the law of squares, the square of the hypothenuse *OD* is equal to the sum of the squares of *OE* and *ED*. But $BD = OA = P_2$ and $DE = BD \sin a = P_2 \sin a$. Also. $BE = BD \cos a = P_2 \cos a$

Then $OE = OB + BE = P_1 + P_2 \cos a$

Therefore, since $\overset{2}{OD} = \overset{2}{OE} + \overset{2}{DE}$.

$$R^2 = (P_1 + P_2 \cos a)^2 + (P_2 \sin a)^2$$
$$= P_1^2 + 2\,P_1P_2 \cos a + P_2^2 \cos^2 a + P_2^2 \sin^2 a$$
$$= P_1^2 + 2\,P_1P_2 \cos a + P_2^2 \qquad (5)$$

since $(\cos^2 a + \sin^2 a) = 1$ (Trigonometry--III, Dec. 9, 1913.)

Assume various values for the angle *a* and see how the values of *R* change. For example, if $a = 90°$ then *cos*

$a = 0$ and $R^2 = P_1^2 + P_2^2$ (equation 1, last lesson). If $a = 45°$ then $\cos a = \frac{1}{2}\sqrt{2}$ and $R^2 = P_1^2 + P_2^2 + \sqrt{2}\, P_1P_2$.

The following table should be verified by the student.

If $a = 0°$ then $R^2 = P_1^2 + P_2^2 + 2\,P_1P_2$ or $R = P_1 + P_2$
$a = 30°$ $R^2 = P_1^2 + P_2^2 + \sqrt{3}\,P_1P_2$
$a = 60°$ $R^2 = P_1 + P_2 + P_1P_2$
$a = 120°$ $R^2 = P_1^2 + P_2^2 - P_1P_2$
$a = 135°$ $R^2 = P_1^2 + P_2^2 - \sqrt{2}\,P_1P_2$
$a = 150°$ $R^2 = P_1^2 + P_2^2 - \sqrt{3}\,P_1P_2$
$a = 180°$ $R = P_1 - P_2$

By a careful study of the parallelogram law it will be noted that the resultant always lies nearest the greater force. If the angle between the forces is less than 90 deg. the resultant is greater than either single force; if the angle is greater than 90 deg. the resultant can only be greater than one of the forces.

A third and perhaps simpler method of determining the resultant of two forces (and this method can be applied where there are more than two forces) is to resolve the forces into their horizontal and vertical components, and then find the algebraic sum of all the horizontal components and the algebraic sum of all the vertical components. Thus all the forces are replaced by a single vertical force and a single horizontal force and the resultant can be found from equation 1, given in Lesson 1.

PROBLEM: Two forces of 80 lb. and 120 lb. make an angle of 30 deg. with each other. Determine the resultant by each of the three methods discussed.

(1) *Graphical Solution*—Draw the lines OB and OA at an angle of 30 deg. with each other (see Fig. 8). Lay off the force $P_1 = 120$ lb. along the line OA to an assumed scale. (It is advisable to always draw one of the forces either horizontal or vertical to simplify the drawing). Similarly lay off $P_2 = 80$ lb. along the line OB to the same scale as used for P_1. Construct the parallelogram and draw the diagonal R. The length of this line multiplied by the scale used will give the desired resultant force. By careful measurement of Fig. 8 the resultant will be found to equal 193 lb.

(2) *Solution by the General Equation*—Referring to the table, when $a = 30$ deg., $R^2 = P_1^2 + P_2^2 + \sqrt{3}\,P_1P_2$. In this problem $P_1 = 120$ and $P_2 = 80$. Substituting these values in the equation there results,

$$R^2 = 120^2 + 80^2 + \sqrt{3} \times 120 \times 80$$
$$= 14{,}400 + 6400 + 1.732 \times 9600 = 37{,}427$$
$$R = \sqrt{37{,}427} = 193.4$$

This value is a trifle larger than that found by the graphical solution. If a larger scale had been used in the graphical solution the error would have been reduced and the two values would have probably checked.

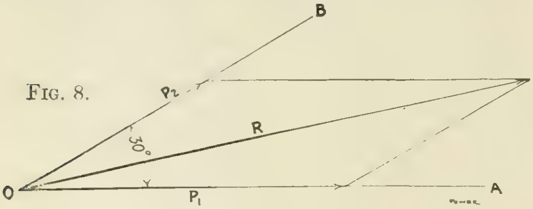


FIG. 8.

(3) *Solution by Components*—The horizontal component of the force P_1 is 120 lb. and its vertical component is 0. The horizontal component of the force P_2 is $80 \times \cos 30° = 80 \times 0.866 = 69.28$ *lb.* and the vertical component is

$$80 \times \sin 30° = 80 \times 0.5 = 40\ lb.$$

Hence the sum of the vertical components is 0 + 40 = 40 lb. and the sum of the horizontal components is 120 + 69.28 = 189.28 lb. From the table when two forces make an angle of 90 deg. with each other $R^2 = P_1^2 + P_2^2$. Substituting the above values there results,

$$R^2 = 40^2 + 189.28^2 = 1600 + 35{,}827 = 37{,}427$$

Therefore, $R = \sqrt{37{,}427} = 193.4$

This value must necessarily check with the value found by the general equation. By using two of the above methods the student can always check his results and thus be certain of their accuracy.

When the resultant of a series of forces is desired it may be found graphically by a continuous application of the parallelogram law. Thus in Fig. 9 let the forces P_1, P_2, P_3 and P_4 be acting on a body at the point O. Construct a parallelogram on P_1 and P_2, giving the resultant R. On R and P_3 construct another parallelogram giving the resultant R_1. Construct a parallelogram on R_1 and P_4 giving as the final resultant the force R_2. This final resultant would be the same irrespective of the order in which the forces are taken, the truth of which the student can readily prove by working the problem.

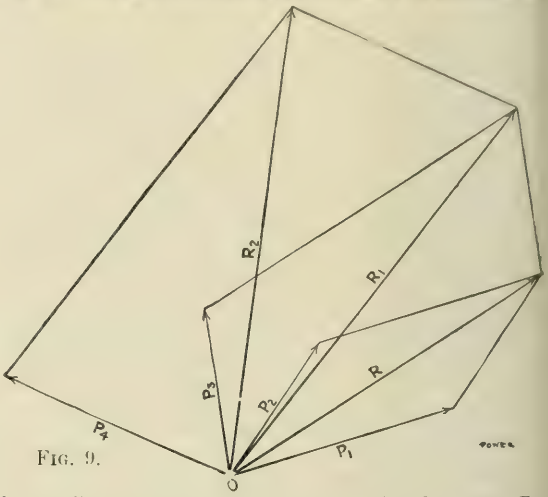


FIG. 9.

STUDY QUESTIONS

6. Define the term resultant force and state three methods by which the resultant may be found.

7. A connecting-rod makes an angle of 12 deg. with the horizontal. If the total pressure on the piston at this point is 6000 lb., what is the connecting-rod thrust?

8. In the above problem determine the pressure between the crosshead and the guides.

9. In problem 8 find the force tending to rotate the crankpin and also the force tending to break the crank. (The force tending to rotate the crankpin must act at 90 deg. to the line of the crank). Assume that the crank makes an angle of 90 deg. with the horizontal.

10. Four forces act on a given body at the point O. The first force is horizontal and equals 50 lb. The second force makes an angle of 60 deg. with the horizontal and equals 60 lb. The third force makes an angle of 30 deg. with the horizontal and equals 40 lb. The fourth force makes 120 deg. with the horizontal and equals 45 lb. Find the magnitude and direction of the resultant.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

BOY, PAGE MISS SPRING!

Spring, Spring, beautiful Spring,
How we do long for the comforts you bring!
The snow and the ice, the pain and the sting—
The Winter we're having is fierce, by jing!
Spring, Spring— There ain't no such thing!

* * *

"The blamed fool didn't know it couldn't be done, so he went ahead and done it," is the slogan of a Kansas commercial club. This fool slogan has a few, a very few, partisans in our own field. And after the accident the scattered remains of the decreased are but poor solace to his widow and children.

* * *

A rural customer of an electric company complained that he was not getting much power, says "Electrical World." In letting the company down easy, the farmer said: "Mebbe it's 'cause our line is overloaded. I notice that the wires are sagging sumthin' fearful."

* * *

The National Efficiency Exposition promoters announce that they will "show Truth in overalls with sleeves rolled up." This is either a sadly mixed metaphor or we have missed the brand of overalls which has sleeves you can roll up. Besides, Truth, like Justice, is popularly depicted as a lady.

* * *

A ton of coal once sold for $2,150,400. Some wise London jewelers spoiled a ton of perfectly good coal by cutting and polishing it and mounting it in scarfpins. They were worn as mementos of the recent great coal strike.

* * *

Us for St. Louis after this! It has a new league whose object is that "whenever they discover conspicuous merit they will report it." We take it that this means that the other fellow will henceforth blow your horn for you, a habit that has fallen into sad disuse.

* * *

Why holler because Mr. Huntington bought a paltry million dollars worth of books from the Dook of Devonshire? Before now, we have bought dooks and lords when we wanted them (or thought we did, at first) as husbands for our fair daughters; and, at that, some of us think the books the bigger bargains.

* * *

UP AGAINST IT

"Say, Billy," remarked Doc. Inquiries this morning, "help me out. I'll be dinged if I can answer this inquiry." It read:

> Can you inform me of any way by which a person in one room, with closed doors, can see what is going on in an adjoining room?

"Only thing I can tell this gink is that it's foreign to our field," says Doc.

"It's foreign all right. D'ye think he's a regular feller, or a Peeping Tom, an abstruse scientist, or one of the suborder Heteroptera—just a bug?"

"Billy, I'm plum worried if he's a kidder, a co-respondent or a sleuth. He's no engineer, that's sure. No engineer would ask such a dum fool question. If I even knew what he was trying to see it would be some satisfaction."

"Now, Doc, that's none of our business, and what we may just guess at might put an innocent seeker after knowledge in wrong. Better get a bill of particulars. Find out if it's a glass door; if there's a transom and a keyhole. Mebbe, it's a case for the police or a psychopathic ward."

"I could send him a choice couplet on that keyhole idea of yours, Spills. You know:

"Ye mighty men of science
Who sweep the heavens o'er
A telescope is nothing
To a keyhole in the door."

Doc, came back an hour later and said he'd hedged. "I dictated an answer, and Floretta McClatchy, my stenographer, made me say that 'the subject of your inquiry is SO FAR INTO our FIELD (I said FOREIGN TO our field, Bill!), which is in subjects pertaining to the generation and transmission of power.' Gee, I feel bad enough to go out and buy myself a headache!"

Poor old Doc, he's sure up against it! And the most of this yarn is true, and all wool—like all good yarns.

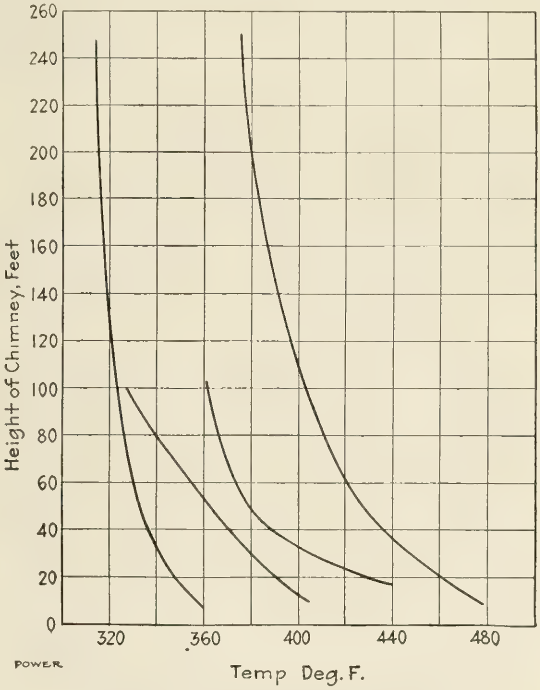
Chimney Draft

Prof. Edward F. Miller, of the Massachusetts Institute of Technology, has been making some interesting experiments upon the temperature of the contents of chimneys. The results are reported in the revision of "Steam Boilers," of which he is the co-author with Prof. C. H. Peabody, and are in brief as follows:

The method commonly used in calculating the draft of a chimney is to figure the difference in weight between a column of cold air of the same height as the chimney, and a column of air which fills the chimney.

The temperature of the air or gases in the chimney is assumed to be uniform and the same as the temperature at the bottom.

This difference in weight (which may be figured for a column of 1 sq.ft. cross-section) is now divided by 62.4 and multiplied by 12 in order to reduce to an equivalent pressure expressed in inches of water.



FALL OF TEMPERATURE IN CHIMNEYS

Many of the theories proposed for calculating the dimensions of chimneys have started with this assumption, and many of the various tables of "Chimney Draft" have been worked out in this way. During the last ten years experiments have been made at the Institute of Technology to determine the draft, and the temperature at different heights in chimneys.

A brick stack 3x3 ft. in section and 102 ft. in height above the grate was tapped at five levels for temperature and draft measurements. This stack, with the exception of 20 ft. at the top, was entirely inside of a building heated to 70 deg.

An unlined steel stack 3 ft. in diameter and 100 ft. in height above the grate was equipped with an iron ladder, and observations were taken at four landings.

In the accompanying chart are plotted curves representing the result of an extended series of observations. The curve *A* gives the variation in temperature found in the unlined steel stack; the curve *B* that in the brick chimney. The curves marked *C* and *D* represent the variation in temperature in a 250-ft. Custodis chimney, 18 ft. internal diameter at the base and 16 ft. internal diameter at the top, located at the L St. station of the Boston Edison Co. This chimney was 3 ft. thick at the bottom and 8 in. at the top, and was taking care of about 50 lb. of coal per sq.ft. of chimney area. The curve *C* was obtained by Messrs. Kilborn and Alexander, of the Massachusetts Institute of Technology, in 1911, and is an average of a large number of curves. The curve marked *D* is a fair representation of another series of curves obtained from the same chimney by Messrs. Rhodes & Walker, M. I. T., 1912. The temperature of the gases entering the stack was much lower in the second series of tests.

These observations of temperature were all taken by means of a thermal juncture which could be moved from the top to the bottom of the chimney and the readings taken, in 30 min. The draft was measured at the base of the chimney and compared with that figured from the average temperature as obtained from the plot. The greatest variation between the observed draft and the draft as calculated was 0.09 in. in 1 in.; in most cases the variation between the observed and the calculated draft was not more than 3 per cent.

⁂

Discrimination in Rates for Electricity

By Henry D. Jackson

SYNOPSIS—It has been stated by the central station that the small consumers, paying 10c. per kw.-hr., are served at a loss, and that the profits come from the large consumers. It is shown in the article that the large consumers of a certain plant cause eight-ninths of the maximum peak load at a load factor of one-third that of the small consumer. Only an unfair division of the fixed and operating costs can account for the great difference in the rates.

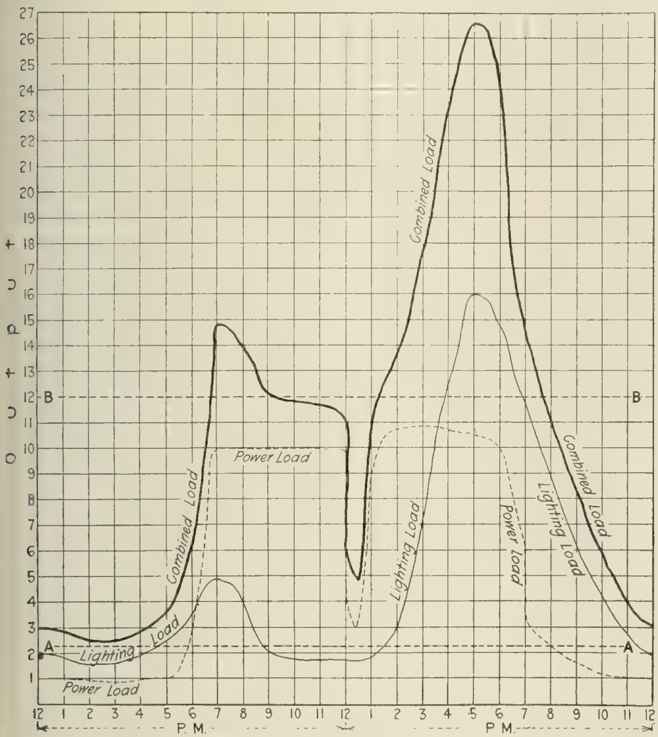
⁂

There has been a lot said in the past about discrimination in the rates charged for electric power. In the course of hearings before the lighting commissioners the general statement has been made a number of times that the average retail customer, who represents approximately 80 per cent. of the commercial customers of the lighting company, are served at an actual loss to the company, and further, that the large companies, those being furnished with large amounts of power at a correspondingly low price, are the ones who return the greatest profits. The general statement of the lighting companies is to the effect that the small consumers are responsible for the peak load, and, therefore, they should, of course, pay for the fixed charges on the apparatus required to produce this load. It is also claimed that the cost of connections to these small consumers is heavy, and, of course, they should pay the fixed charges on these connections. It is still further claimed that the amount of power furnished to these consumers is small and that the management and operating costs are, therefore, necessarily large as compared to these charges against the large consumers.

Referring to the accompanying illustration the peak load is composed of the power load and the peak of the lighting load, this lighting load peak being composed of the large users and the small users. It is quite evident from the rapid dropping off of the peak lighting load that the majority of this load is composed of the large users, such as stores and factories. A rough calculation would show that the small consumers or those paying the maximum price, are actually responsible for but one-ninth of the maximum peak load; the other eight-ninths being composed almost entirely of the large users of light and power. A portion of this load is municipal lighting, which, while entering the peak load, is a load of long duration and exists during the entire year. This, then, would indicate that the small customers' load would be responsible for but one-ninth of the total apparatus in the station and but one-ninth of the apparatus in the streets. This latter is to be modified somewhat, because of the connections required from the streets to the service of the small customers; but this is a small item when taken in connection with the total cost of apparatus required for the generation and distribution of the peak load, so that so far as the fixed charges are concerned, slightly over one-ninth is actually chargeable against the small consumers.

To be sure, the power furnished to each individual consumer is small, but the number of those consumers is very great and the total amount of power furnished to these consumers represents 28.2 per cent. of the total amount of power generated by the company. This would hardly be called small. The operating charges, however, for this power may be fairly large, not, however, in the station, but entirely in the management and distribution, because the meters must be read and kept in order, the bills must be rendered and must be collected. These items cost money, and should be charged up against the people causing them. On the other hand, the large consumers are responsible for an item of management cost, which probably would go a long way toward offsetting these charges against the small consumer, and this item is the large corps of assistants or solicitors and engineers who are necessary in order to obtain this load as well as to maintain it. These men are trained specialists, and cost a large amount of money to employ. They act in an engineering capacity for the consumers, furnishing them with information, data, etc., to keep the consumer satisfied. These men have no connection whatever with the small consumers, and, in fact, the small consumer rarely knows that such men are available, so that the cost of these should be charged against the large consumer. Thus the management charges against the two characters of load per kilowatt-hour would probably be very nearly the same.

It is to be noted, however, that while the load which is responsible for 11 per cent. of the maximum peak load, consumes 28.2 per cent. of the power actually delivered by this lighting company, the remaining load which is responsible for 89 per cent. of the maximum peak consumes but 71.8 per cent. of the total output, showing that the load factor of the small consumers is considerably over three times that of the large ones, so that the actual operating costs in the station for the small consumers should be considerably less than that of the large ones, as a constant load factor materially improves station operation. The load factor of the small consumers' load has also a very important bearing on the fixed cost, because the better the load factor, the lower should be the fixed cost. Under these conditions, therefore, it would seem as though the small consumers' load should not be responsible for any great excess fixed or operating charges over those charged against the large consumer.



COMBINED SUMMER AND WINTER LOAD CURVES

What, then, is there to make the cost of power to the small consumers so much greater than that to the large one? One thing which exists is the fact that the large users use power during the day when the machinery would otherwise be idle. This would be a just cause for a low rate if the power furnished could be furnished from machinery which was used for producing power for other purposes during the peak load.

The curve shows distinctly the existence of a condition exactly opposite to the general statement of the lighting companies—that is to say, the power furnished during the day to the large consumers is furnished by machinery which has a capacity equal to that machinery necessary for the production of the same power during the peak load, or, in other words, having this load during the day, and the fact that it extends into the peak period, requires a station capacity equal to this day load. This condition then should make it necessary that the fixed charges should be paid by those consumers requiring that machinery. As above stated, the ratio of apparatus is approximately 1 to 9, or eight times as much apparatus is required for the peak lighting and power load of the large users as is required for the combined load of all the small consumers.

If, then, the small consumers are responsible for one-ninth of the total fixed charges, including dividends, the cost to the consumer for these would be 1.298c. per kw.-hr., and the fixed charges against all the rest of the consumers on the basis of eight-ninths would be 4.31c. Assuming that the total charges per kilowatt-hour are equal, the operating charges against the small consumer would be 4.97c., and against the large, 1.96c. The receipts per kilowatt-hour for the small customer are 10c., and for the balance of the power sold average 4.75c. Evidently on these figures the small consumer is paying a considerably larger proportion of the charges than is warranted.

Suppose, then, that for some reason the small consumer should pay for double fixed charges. We then find that the fixed costs for the small customer, including dividends, are 2.596 and for operating 4, making a total of 6.596. The fixed costs, including dividends, for the large customer are 3.706 and the operating cost 2.424, which totals 6.13. The average receipts remain as before.

Again, if the small customer pays for the entire amortization and taxes charge, and something over double the *pro rata* dividend charges, and his fixed charges and operating costs are made equal to the price received per kilowatt-hour, the charges will be: Fixed, 6; operating, 4. The charges to the large consumer will reduce to: Fixed, 2.326; operating, 2.424, making a total charge of 4.75, or equal to what the average figure for the power delivered to the large consumer has been, according to the reports in the past. Under these conditions, it is evident that power sold below 4.75 is sold at below the actual cost total of operation and dividends, and that any power sold below 2.424 will return no profit to the company, and any power sold between 2.424 and 4.75 is only paying a proportion of the fixed costs and dividends.

How, then, is the small consumer being sold to at an actual loss, when he pays 10c. a kw.-hr., and how is it possible for the large consumer to be sold to at a profit at prices as low as 1.44c. per kw.-hr.?

It is evident from the above that the figures regarding both fixed and operating costs can be made to meet any condition that may be desired. The lighting company can readily adjust the figures so that the total cost of fixed charges, plus operating charges, will show a loss on selling power at 10c. and a profit on selling power to the large consumers at any price. It should, however, be noticed that such figures are merely juggling. The facts must lie somewhere between the first set of figures given and the last.

Chicago Section A. S. M. E. Holds Banner Session

On the evening of Mar. 18, in the Crystal Room of the Sherman House, the Chicago section of the American Society of Mechanical Engineers held its best meeting of the year. The subject was "Large Steam Power Plants," and some of the best engineers in the country in responsible charge of the largest plants were there to discuss the various phases of present day operation and suggest improvements for the future. Over two hundred were at the table, and all were enthusiastic over the rare treat of listening at one sitting to such men as Moultrop, of the Boston Edison, Parker, of the Detroit Edison, Hunter, of the St. Louis Union Electric, and Abbott, of the Commonwealth Edison, of Chicago. W. B. Jackson, of Chicago, officiated and made an excellent toastmaster.

THE BOSTON WAY

I. E. Moultrop introduced his remarks on the topic of the evening with a short talk on the work of the society. He was highly in favor of geographical meetings as the strength of the national body lay in the local organization. A step farther is the joint meeting with other societies which have proved so beneficial in Philadelphia, St. Louis and other cities. It is important to get all the engineers out. The lines are not very distinct. All are engineers, and the intermingling and the exchange of ideas will help the profession as a whole. At the annual and spring meetings papers of high grade are expected, but at local meetings this is not so necessary. A topic should be selected that will draw the engineers to the meeting and get them on their feet in the discussion. Finances, the amount allotted to the local organizations, and the importance of increasing the membership were also touched on.

Continuing, Mr. Moultrop turned to the boiler room, to which the present-day engineer is directing much attention to secure better economy. This is as it should be, because the oepration of the boiler room will show, in better fuel economy, any increase of skill and intelligence devoted to that part of the plant.

Most plants are subjected to great and sudden variations in load. In the electrical end of the station there are all sorts of instruments which are closely accurate, but only recently has some thought been given to installing instruments in the boiler room. Originally, all that a man had was a water glass and a steam gage. A visual load indicator was then added and the next instrument was a device that has created a lot of discussion, the CO_2 recorder. This is a delicate instrument, and where it has been put into the boiler plant and received the best of care and atention, it has been of some use. But it is a laboratory instrument and not for the average fireman. The difficulty is to get a fair sample, as the qualities vary greatly in different parts of the cross-section of the gas passage. A sample taken from one place may be much different from that taken from another point in the same flue at the same time.

One of the most satisfactory instruments now in use is the steamflow meter. Used in connection with draft gages, draft regulators, feed-water regulators, etc., the fireman can show a considerable amount of intelligence in operating a boiler plant.

In the usual large station a high chimney is necessary to carry off the gases. Ordinarily the height required is enough to give the draft needed under normal conditions. But the exacting requirements of public-utility plants call for more positive control over the draft, and the ability to meet sudden demands for load calls for forced-draft apparatus.

The best arrangement is a plant that will run on natural draft, with some cheap apparatus for materially increasing the draft to meet peak loads or unexpected demands. At the L St. station in Boston the situation has been met by using Murphy stokers, closing up the ashpit and creating forced draft with steam jets. The load is carried on natural draft up to 150 per cent. of rating. Above that the ashpit doors are closed, the steam blower turned on and it is possible to reach 300 per cent. or over. Boilers have been taken from 125 to 300 per cent. inside of five minutes.

In the past too much attention has been given to the operation of the turbine or engine room and not enough to the boiler plant. The usual practice has been to put the high-priced and high-grade engineer in charge of the generating room and hire some brawny individual to shovel coal into the boiler. The economy of the turbine room is mostly in the hands of the designing engineer. In the fire room the constructing engineer does not have much control over the economy. When it is considered that from 60 to 70 per cent. of the cost of putting a unit of electrical energy onto the busbars is spent in the fire room it does seem that this is the place to have the most skilled help. The fire-room job has been dirty, underpaid, unpleasant and unattractive in every respect. The mechanical stoker has changed this in many respects. It should be arranged to do away with all manual labor, make the place light and clean, and give the man in the fire room sufficient instruments so that he can tell what he is doing. This will make the job attractive to a young man and it will be possible to get better help in the fire room.

BOILER PRACTICE IN DETROIT

Coming from the Detroit Edison Co., with its large boilers at Delray and more to be installed in the new station at Conners Creek, J. W. Parker naturally talked of those immense units and their operation. In his opinion, the large boiler had created a good deal of criticism just because it was large. Some people object to putting so many eggs into one basket, but, quoting from Carnegie, "he preferred to put them all into one basket and watch the basket." Boilers are more reliable units than steam turbines. It is possible to lose a large turbine much quicker than a large boiler. The company had never lost one of its large boilers when it was needed, and during a peak never had a tube burst.

As to tube troubles, the water was not very bad. In a year or 18 months, upon opening a boiler, about $\frac{1}{8}$ in. of scale was found on the front tubes. With a unit driven only during the peak at about 175 per cent. of rating, $\frac{1}{8}$ in. of scale is not serious, but with the double-ended boiler the trouble from radiation seems to be greater. Everything is radiating right at the front tubes, and when running at 200 per cent. of rating but little scale is permissible. The only trouble in this direction had been a small bag about the size of a quarter, and this was not discovered until the unit had been cut out and inspected.

Even $\frac{1}{8}$ in. of scale is too much to stand for, however, and the water should be cleaner. A small amount of barium hydrate had been used, but Mr. Parker was in favor of using distilled water for make-up. It does not cost much except the radiation from the distilling apparatus because it is possible to distill the make-up under vacuum. By using it the amount of blowoff can be reduced to 2 per cent. Trouble from corrosion can be lessened by feeding a certain amount of lime.

In reply to Mr. Hunter, the speaker said that they had used compound much as people buy and take patent medicine, getting enough foam to cause flooding of the superheater tubes and their constant burning. The barium hydrate is fed in the same way as any compound and it controls the scale formation in the same way, but avoids foaming. The barium sulphite precipitate was so fine that it could not be filtered out, and they were using a little sodium in combination with it, but this compound was simply used as a makeshift until the experiments on the practicability of using distilled water for make-up had been worked out.

One of the advantages of a large boiler is that the company can afford to use more instruments, employ better men and pay more attention to the single unit. The Detroit Edison has just started the foundations for a station of 120,000-kw. normal capacity. It will have 12 boilers, each of which will ordinarily care for 10,000 kw., and there will be no spares in the plant. By installing forced-draft apparatus and taking care that the stacks and breeching are ample, it will be possible to get 250 per cent. of rating out of each boiler. Each turbine is served by two units, and running at the above rate one boiler out of every four could be spared.

The boilers at Delray have done so much more than was expected of them that there is too much boiler capacity. During the peak season of 1913 no banked boilers were carried, which means a large saving. It is hard to realize how much of a disadvantage a low load factor is. Boilers which show high efficiency under a constant load will not show up as well under variable conditions.

To take advantage of the possibilities of large units it is necessary to study conditions. At Delray they started in with boiler tests and studied carefully the things that seemed to be indicative of good efficiency. In this connection the CO_2 machine has been a most valuable instrument. They have been able to keep it running and the firemen trusted it. Samples are drawn from four different points in the setting and are mixed automatically to obtain an average sample. The recorder is mounted on the front of the boiler where the firemen can watch it. There are also steam-flow meters and draft gages, but Mr. Parker did not know of any better instrument than the CO_2 recorder to show good firing and poor firing conditions. The flame is watched where it leaves the furnace and enters the first pass. If there is a slight haze there it means that there is some slight flame over in the pass, and if it gets a little bit heavier there is danger that the gases will be cooled down and go out before the combustion is complete.

It is possible to get a beautiful looking combustion chamber and good-looking second pass by using an excess of air and still have bad combustion. There is no better way to detect it than by the use of the CO_2 machine. From 13½ to 14 per cent. of CO_2 is obtained as an average when the boilers are running steadily. Conditions are disturbed a little about noon and the records show perhaps 10 per cent. As the boilers are run harder the CO_2 rises. It is common to get 16 to 16½ per cent. at 225 per cent. load, and checking with the Orsat, there is no more than a trace of CO. It is not a good idea to draw two lines on the CO_2 chart and tell the men to keep between them.

As at first installed, the control apparatus of the big boilers was clumsy to control. The damper was handled from a gallery 20 ft. above the men's heads. They had no steam-flow meter. Efforts have been made ever since to bring the control under the hand of the fireman, so that he will have all the advantages of the testing engineer when running a test on a boiler. The men can control everything from one point and all the instruments are on one board.

It has naturally come about that everything is hand-controlled and automatic regulation has not been tried because it was desired first to find out what there was to do. It would then be easy and desirable to install automatic apparatus.

With hand control, it is possible for one fireman to handle two of these large boilers. In addition, there is a roving fireman over every nine boilers. Firemen who have been in the service 2 or 2½ years are receiving 40c. an hour, and the company is rapidly getting to a point where the highest-priced and brainiest men must be placed in the boiler room. Ordinarily a change from the boiler to the engine room has been considered a promotion, but under the new conditions the engine room will have dropped to a secondary place. In making transfers it is important that the men realize this, as otherwise there is apt to be trouble and dissatisfaction.

As expressed by Mr. Stott at the annual meeting of the society in New York, it would be a fine thing to have college graduates for firemen. This is not impossible by any means. The dirty work could be handed over to helpers and the real brainy work entrusted to them. A preliminary training of this kind in the boiler room for a year would be invaluable, and to the right man the job would be so interesting and worth while that he would be willing to do the actual firing.

AT ASHLEY ST. STATION, ST. LOUIS

John Hunter referred briefly to the organization of the first local section of the society in St. Louis in 1909 and then turned to his subject, "The Construction and Development of Large Steam-Power Plants." In St. Louis this line of work had been arrested for the past two years due to the development of the large hydro-electric plant at Keokuk, from which 60,000 hp. at 110,000 volts is transmitted over two transmission lines to St. Louis, a distance of 145 miles. At a substation in St. Louis County this is stepped down to 13,200 volts, 30,000 hp. being delivered to the street-railway company and 30,000 hp. to the lighting company. The lighting company's energy is carried underground at this voltage, a distance of seven miles, to a substation adjacent to the main steam-generating plant, where it is stepped down to the steam-generating voltage of 6600. In the steam station there are three distinct systems of service; the street railways, 25-cycle, the Union Co.'s service for industrial power and business lighting, which is changed to direct current, and 60-cycle service for residence lighting. The water-power energy is connected directly to the busbars of the steam generators, the two systems floating together in parallel.

To insure continuity of service the steam station has been maintained as a standby ready to pick up the water-power load in the shortest possible time. The prime movers are either in on the busbars, or floating, ready to pick up the load, which is an easy method of operation. The condition is much different in the boiler room. It was found from test that it would take 130 lb. of coal per hour to bank the fires in each boiler and hold it at about 60-lb. steam pressure, and as all of the boilers are equipped with chain grates, which are slow-moving units, it would require about 30 minutes to bring them in on the header with the fires in such condition that they could maintain the desired capacity.

To bring the boilers quickly into service at less cost a unique system was developed of keeping the water hot in the reserve boilers with fuel set on the grates ready to ignite at a moment's notice. A tank with a steam coil was placed in the basement directly below the battery of standby boilers. The blowoff headers from these boilers were connected to the bottom of the tank, and to the top the superheater connections to the steam drums. The difference in elevation of these two connections to the boilers caused an easy circulation. The steam coil in the tank was connected to a drain of one of the main steam headers of the standby boilers which were kept alive for emergency service. This connection not only served to drain the header, but also to heat the water for the idle boilers, and maintain it at a temperature of about 212 deg. at a cost by test of the heat equivalent of about 12½ lb. of coal per hour. The boilers can be cut into service and maintain their capacity in about 15 min.

Quick ignition of the fires has been solved by laying on the grates, which are 10x10 ft., two rolls of oily rags, crosswise and lengthwise, covering the remainder of the grate with a high-grade washed nut coal about 1½ in. in size to a thickness of 9 in. Kindling wood soaked in oil is placed on the top of the coal. This fuel may stand any length of time without deterioration or cost. On ignition it bursts into flames and the generation of steam is rapid.

In maintaining hot water in standby boilers it is important to keep the dampers tight so that there is no circulation of air in the boiler. In this way the brick setting is kept hot. The firebrick suffers little from the heavy action of the flames when the fires are started. One complication which arose during the past six months was a pitting action in the drums. Most of this pitting was in the vicinity of the water line and was evidently the result of galvanic action between the metal of the boiler drums proper and particles of carbonaceous matter adhering thereto. Further action was prevented by cleaning out the corroded spots, scraping and wire-brushing the entire inside of the drums and applying two coats of graphite paint, permitting each coat to dry thoroughly.

To prevent the possibility of further action of this sort, the method of treating the boiler-feed water was changed. The plant in St. Louis is on the banks of the Mississippi River, which contains a high percentage of silt, sand and organic matter. This water is clarified for boiler purposes with a coagulant of lime and sulphate of iron, adding a small percentage of soda ash to relieve it of its permanent hardness. The use of this soda ash results in the concentration of sodium sulphate in the boilers, and as this is strongly alkaline, it was thought that it served as an electrolite for the galvanic action taking place between the particles of carbon and the iron. The company has just begun using barium hydrate instead of soda ash to remove all of the organic matter and a large portion of the sulphate, or permanent hardness, from the water before it enters the boiler, at the same time avoiding the presence of an alkaline solution in the boilers.

Mr. Hunter then referred to an experience with the cooling coils in the high-tension transformers of the hydro-electric system. The coils in these transformers were of iron, and although the current was alternating, it was found that the coils were in a strong magnetic field and were highly magnetized. After being in service for six months the inside of the coils had deteriorated rapidly, indicating galvanic action. The pipes had also become heavily coated on the inside with mud which had been deposited from the water flowing through them. This deterioration and accumulation forced a change from iron to brass coils in which there is no accumulation of any kind.

The effect water-power operation had on the coal supply on the St. Louis market is interesting. A year ago at the Ashley St. station before the water-power service went into effect, something over 1100 tons of coal per day were burned; now only half that amount is used. This falling of in the coal consumption by the lighting company and a like amount by the street railways company caused a large amount of screenings to be thrown on the market, which effectively lowered the prices of all screenings shipped from the mines in the vicinity. The railroads handling this coal and also the Terminal Railroad Association suffered a material loss by the reduction in the number of cars of coal handled per day.

Previous to receiving water power, the peak load in the Ashley St. plant was 55,000 kw., which required a crew of 122 men for operation only, including coal and ash handling. The steam-generated peak this winter, in addition to the water power received, was 34,400 kw. The operating crew for this load and for emergency service should the water power fail and the station be required to pick up the entire load, is 87 men.

Through the increasing demand for energy the installation of new machinery in the Ashley St station brought about many points that had to be worked out to meet the special conditions. Among these were the condensers originally installed for the 5000 kw units, which with their auxiliaries afterward served the 12,000 kw turbines. The ratio of cooling surface to capacity on the old units was 1 to 1, while on the new installations it was reduced to 1.6. With the old condensers and the larger load there was a serious congestion in the upper bank of tubes. To relieve this congestion and trouble with packing leaks caused by the vibration of the tubes due to the high velocity of the steam, it was necessary to open up the top and center banks, taking out three rows of tubes in three places on both banks. This permitted the steam to be carried well down into the condenser and materially relieved the high velocities, giving a much closer balance in pressure between the top and the bottom of the condenser and at the same time obviating all trouble in the packing at the tube ends.

A point worth mentioning in connection with the steam end of the 12,000-kw. turbines, was a weakness that developed in the third-stage diaphragm nozzles. This, in Mr. Hunt's opinion, was brought about by the unequal expansion in the diaphragms, causing the thin nozzle plates to crack and in some cases to break out. This weakness was overcome by a change in the design, the nozzles being cast of brass in sectional plates. These plates, being portable, can be removed without dismantling the machine, although with the new design it was thought that it would never be necessary to remove the sections. Outside of this weakness the operation of these turbines has been most satifactory and the maintenance cost practically nil.

It would appear with the advance in the art and the higher capacities of machines being manufactured, that the leaning is toward the horizontal machine. Some two years ago two 4000-kw. units were installed in the station and have given excellent satisfaction. The 20,000-kw. unit now being contemplated will be located in the space occupied by a vertical cross-compound reciprocating engine of 3000-kw. capacity, and as the demand for energy increases, 20,000-kw. units can be installed in the space now occupied by two other 3000-kw. reciprocating engines. This prime-mover capacity, of course, will be governed by the space available in the station for additional boilers.

SUGGESTIONS FROM CHICAGO

To reduce the cost of producing electrical energy, W. L Abbott agreed with the preceding speakers that the boiler room was a good place to start. A boiler with its furnace he had frequently described as a piece of apparatus for heating air and cooling it. The air is a medium for transferring heat from the fuel to the water in the boiler. Suppose a transfer of water was being made from one vessel to another and the cup with which the transfer was made each time was completely filled and emptied, there would be no loss. Filling the cup in one vessel, emptying two-thirds of it into the other and throwing the balance away would duplicate what is being done in the boiler room. Air is taken at a normal temperature, heated up to 2000 or 2500 deg., and cooled down to 500 or 600 deg. The rest of the heat is used to create a draft—that is, the air is driven up a smokestack, pulling fresh air after it through the fuel bed. To use 20 per cent. of the heat of the fuel merely to push air through the fuel bed is a wasteful process. It is true that the temperature of the water in the boiler is some 400 deg. and cannot cool down the air. The remedy is to use economizers and cool down the furnace gases to the lowest point possible. Mr. Abbott would, therefore, abolish smokestacks for the purpose of creating draft. Boilers are being forced 100 per cent. every day, and with forced draft from 300 to 400 per cent., and still the limit has not been reached. The speaker suggested that the boiler be cut in two and half of it be forced to 500 per cent. if necessary. The other half could be used as an economizer in two stages if need be, and the gases cooled to the temperature of the feed water. In this way there is a possible saving of 20 per cent.

Another medium for transferring energy is steam. It is loaded up with heat in the boiler and in the superheater and then in expanding it through the turbine the attempt is made to get back from the steam as much of that heat as is theoretically possible. Here is the place where practice fails. Conceive a sawmill steam plant with a leaky teakettle of a boiler, the engine out of line and without any packing. Compare that with the modern high-pressure, low-vacuum turbine installation, and an approximate comparison between the thermal efficiency of the modern equipment and the actual amount of energy in the steam is obtained.

To get from the steam as it goes from the turbine 20 per cent. of its energy is doing very well. Four-fifths of it goes to the condenser. The only way to get a greater percentage of this heat is by raising the initial pressure and temperature of the steam as it enters the turbine and by reducing the pressure and temperature as it leaves the turbine. Progress is being made slowly in the higher pressures and temperatures, but the possible saving in this direction is small as a little increase in the temperature is accompanied by a considerable increase in pressure.

On the other end, it is common to discharge the steam into the condenser at a pressure 1 or 2 lb above absolute. This looks to be inconsequential compared with 200 lb initial pressure, but in this 1 or 2 lb pressure which has been sacrificed at the lower end is 50 or 75 deg. of temperature; this is a waste for which the engineering fraternity can make no apology. It appeared to the speaker that there had been less horse-sense employed in the design of condensers than in any other part of the steam equipment. The manufacturers seem to think that a condenser is like a boiler, and that its purpose is to cool down the steam. The steam is passed up and down through a bank of thickly spaced tubes at a velocity almost equal to that of a high-powered bullet, for they apparently believe that if it is good practice in a boiler it must be in a condenser. The steam can get through only by piling up on the back pressure. To obtain greater economy in the engine room, make a condenser with the greatest possible area for the steam to strike the tubes, so that all of the cooling surface is immediately available for the steam when it enters the condenser. Instead of passing through a long constricted passage full of tortuous baffles, it can then get in contact with the cooling surface at low velocity and be condensed. A gain of 1½ in. of vacuum represents an increase in the power from the turbine of 25 per cent.

Two other suggestions were made for increasing the efficiency. The cost to put current on the busbars does not consist alone of operating costs. It consists equally as much of the fixed charges on the cost of the power house and equipment. Take the cost of operation of a plant, multiply it by 2, and the cost of operation plus the fixed charges will be obtained. This more nearly represents the cost of the output. For a further reduction of this cost reduce the cost of the power house. This is a bright idea that perhaps would not occur to the gentlemen designing power houses. By putting on some filagree, and perhaps a steeple, they forget they are loading up that power house and that community with an increased cost on all the energy made in future years.

To get the lowest cost, the equipment cannot be duplicated to guard against some contingency which may occur in this decade or the next. The size of the average power house and the amount of equipment in it should be reduced. With the usual power factor the apparatus on the average is busy about one-third of the time; about one-fourth of the apparatus is busy only 2 or 3 per cent. of the time. In the course of the year, if the power house is fully loaded at the time of maximum load, there is only one or two hundred hours that the whole of the equipment is used; that last quarter of the equipment should not be installed. Then by reducing the cost of the power house by one-quarter the cost of the output will be cut 12½ per cent.

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First National Efficiency Exposition

The First National Efficiency Exposition and Conference is to be held April 4 to 11 at the Grand Central Palace, New York City. Governor Martin H. Glynn is expected to make the inaugural address.

Among the exhibitors are the Public Service Commission of New York, New York Telephone Co., Bush Terminal Co., Interboro Rapid Transit Co., Equitable Building Corporation, General Acoustic Co., Thomas A. Edison, Inc., Remington Typewriter Co., New York Edison Co., Burroughs Adding Machine Co., Alexander Hamilton Institute, General Vehicle Co., the Joint Board of Sanitary Control, Brandt Cashier Co., Cowan Truck Co., Edison Storage Battery Co.

The Conference will concern itself largely with the discussion of papers having a direct bearing on the exhibits on display. Many prominent industrial engineers will attend these conferences, and invitations are extended to municipal authorities, chambers of commerce, merchants' associations, and scientific and labor organizations.

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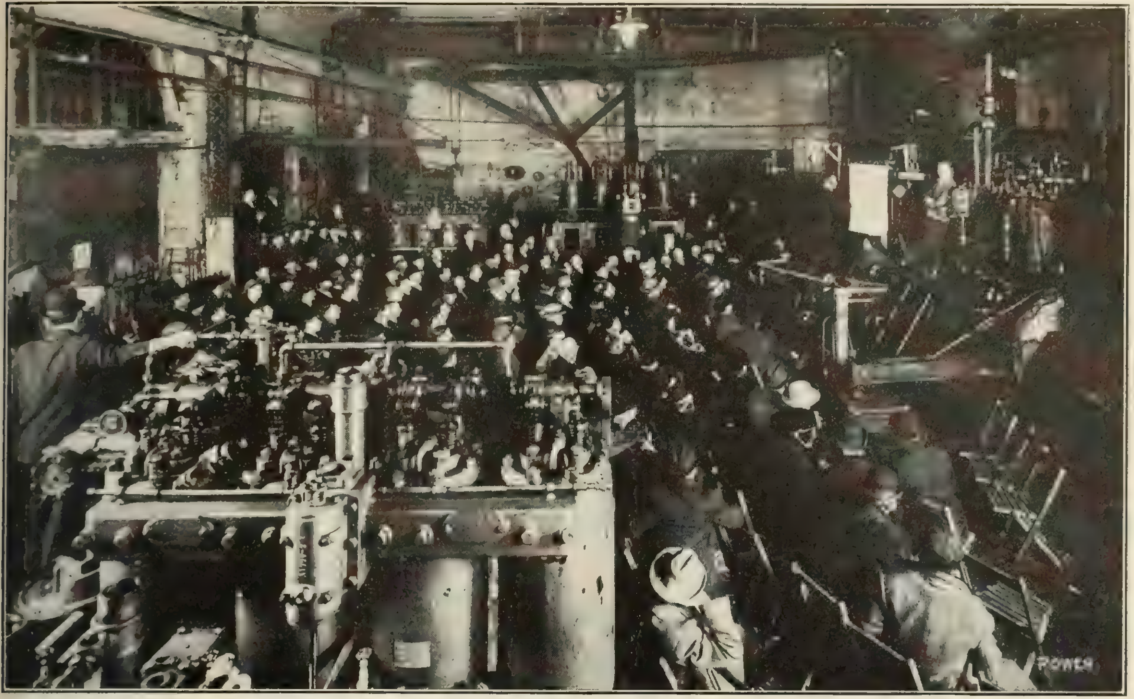
The Collection of Watt Relics, assembled by Wm. Darlington, for many years the general manager of the works at Soho, and later acquired and added to by George Tangye, who operates the Soho works and occupies Heathfield Hall, the home of Watt in his later days, has been presented by Mr. Tangye to the city of Birmingham, which will make provision for its preservation and exhibition.

Waste-Heat Boiler

On the evening of Mar. 6, the Cleveland chapter, N. A. S. E., was entertained at the works of the Bruce-Macbeth Engine Co. by J. B. Meriam, in a lecture on a new exhaust boiler which has recently been developed by that company. The photograph was taken during the lecture and shows a 150-hp., four-cylinder gas engine equipped with an exhaust boiler. In the ordinary gas engine about 30 per cent. of the heat in the gas is wasted to the jacket water and about 35 per cent. in the exhaust cases. By circulating this water very rapidly through the jackets in connection with the boiler which utilizes heat from the exhaust gases a significant part of the waste heat is recovered in the form of low-pressure steam.



Photograph Taken during Lecture on Waste-Heat Boiler

It is understood that the Case School of Applied Science is to conduct extensive tests on the boiler.

Recent Court Decisions

Digested by A. L. H. STREET

Knowledge of Danger Presumed—As affecting an electric company's liability for injury to, or death of, one of its employees, caused by electric shock, the company is presumed to know all dangerous conditions that are known by its head electrician, or could be known on proper inspection. (Oregon Supreme Court, Myers vs. Portland Ry., Light & Power Co., 138 "Pacific Reporter," 213.)

Rights in Public Lands—The act of Congress of May 14, 1896, empowering the Secretary of the Interior to grant rights-of-way over and use of public lands to electric-power companies, supersedes earlier legislation, so far as concerns the acquisition of rights since the law was adopted. (United States Circuit Court of Appeals, Eighth Circuit; United States vs. Utah Power & Light Co., 209 "Federal Reporter," 554.)

Handling of Live Wires—A member of a city fire department who was stationed near a live wire to keep pedestrians away from it, was guilty of contributory negligence in attempting to break the wire with his bare hands, precluding recovery for his death against the electric company which owned the wire, although he was not an electrician; he being a man of mature years, it was unnecessary to warn him against the danger of coming in contact with the wire. (Wisconsin Supreme Court, Glander vs. Milwaukee Electric Railway & Light Co., 144 "Northwestern Reporter" 972.)

NEW PUBLICATIONS

Der Dieselmythus

TRUE HISTORY OF THE DEVELOPMENT OF THE PRESENT OIL ENGINES—By Prof. J. Lueders. Royal Technical University, Aix-la-Chappelle. Size 10x6½ in.; pages 236; 12 figures. Price 4½ marks. Published by M. Krayn, Berlin W., Germany.

Since the Diesel oil engine has reached such a degree of perfection that many notable concerns have taken up the manufacture of this efficient motor, it might probably be of interest to many to know more about the origin of this motor and still more about its originator. All those who are interested in oil engines, whether from the scientific or commercial side, will probably never question the truth that Diesel was really the inventor of this famous engine. The commercial man might be very little concerned over this question but the engineer and student will probably want to know more about the early experiments carried on by Diesel and his associates.

The question raised by the author of this book, as to whether Diesel really deserves to be recognized as the inventor and constructor of the high-compression oil engine, may now be considered timely.

In order to be able to answer this, the author makes a careful investigation of all Diesel patents, his experiments, etc., and after analyzing the various propositions made by Diesel in respect to the construction of his motor, he comes to the conclusion that Mr. Diesel actually contributed very little to the development of the oil engine. In fact the author goes so far as to absolutely under-rate Diesel's ability to do such work. The methods adopted by Diesel during the experimental period, it is claimed, were so unscientific that, were it not due to his able assistants and collaborators, he might never have perfected the engine. That Diesel did not have the necessary qualifications of an inventor and that his success was merely due to his exceptional business ability are only some of the assertions made by the author. To form an opinion about the personal relation of the author to Diesel would be very difficult and at the same time to mention the words "professional jealousy" would probably be unjust, as we cannot conceive that a man such as Prof. Lueders should pursue more than scientific interest in the question.

In thus severely criticizing Diesel, Prof. Lueders regards it as his duty to expose the past of a man who he considers has done nothing more than give the impulse to this new motor and should therefore not be considered as its "inventor." It is only to be regretted that Diesel disappeared before this book reached the public.

The book is well arranged and written in an interesting style. In the preface the Diesel question is generally discussed and the meaning of the word "Dieselmythus" explained.

The first Diesel patents of 1893, his first pamphlet and the criticism of it are treated in three chapters. A very elaborate chapter is devoted to the Diesel experiments from 1893 to 1897. Prof. Schroetter's and Diesel's lectures in Cassel, 1897, and their critics are then separately discussed, followed by a chapter on Diesel's lecture in Berlin in 1912. Diesel's article on the origin of the Diesel motor (1913), which according to the author is only a reprint of his Berlin lecture, covers the last chapter of the book.

Government Publications—The third annual report of the Director of the Bureau of Mines, 1912-13, J. A. Holmes, director, containing 118 pages and one plate, is ready for distribution and may be had by addressing the Director of the Bureau of Mines, Washington, D. C.

Technical paper 57 giving a preliminary report on the utilization of petroleum and natural gas in Wyoming, by W. R. Calvert, 1913, 23 pages, is also ready for free distribution.

Civil-Service Opportunities

COMPETITIVE EXAMINATIONS *for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commissions. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.*

Situation for Heating and Ventilating Engineer and Draftsman—The United States Civil Service Commission announces an examination for heating and ventilating engineer and draftsman, on Apr. 22 and 23, 1914, to fill vacancies in this position at $1200 per annum, in the Office of the Supervising Architect, Treasury Department, Washington, D. C., and in positions requiring similar qualifications. Subjects: Practical questions in heating and ventilating; drawing and design; training and experience. Applicants must have had not less than four years' practical experience in designing or installing heating and ventilating systems, of which a technical degree will be considered equivalent to not over 2½ years.

Applicants must be examined in the state or territory in which they reside and have been resident therein at least one year. Apply to the United States Civil Service Commission, Washington, D. C.

ENGINEERING AFFAIRS

On Friday evening, March 6, William T. Dempsey, of the arc light department of the New York Edison Co., delivered a lecture to the students of the New York Electrical School on "The Street Lighting System of The New York Edison Co." Mr. Dempsey illustrated by means of lantern slides the various results that are produced by different systems of lighting. His interesting and instructive lecture was enjoyed by a large representation of the student body of the school.

The American Society of Mechanical Engineers' spring meeting will be held in St. Paul, June 16-19. At one of the three main professional sessions powdered fuel will be discussed, and preliminary reports will be presented by the committee to formulate standard specifications for the construction of steam boilers and other pressure vessels and for their care in service and by the committee on flanges, the latter paper having been presented for preliminary discussion at the last annual meeting.

At the regular March meeting of the Massachusetts chapter of the American Society of Heating and Ventilating Engineers, W. H. Myrick, president of the chapter, reported that he and the secretary had represented the chapter at a hearing before the Recess Committee No. 2113 of the state legislature in opposition to House Bill No. 928, which provides for placing the ventilation of school houses of Massachusetts under the supervision of the State Board of Health. The objections to the bill, which had been offered in behalf of the chapter, were that ventilation is inseparable from heating, that the bill made no provision for appeal from the decision of the intelligence of the State Board of Health, and that no penalty being provided, the measure, if enacted by the legislature, would be devoid of force. The report of the president was indorsed and especially commended by the members for the arguments that had been advanced with respect to the dearth of knowledge possessed by average physicians and public health officials as to rational requirements and practical operation of ventilating apparatus. Attention was also brought to the wide disparity of opinions of members of the medical profession respecting requirements of ventilation.

Secretary Prosser, of the National Society for the Promotion of Industrial Education, calls attention to the training class for the preparation of shop teachers in industrial and trade schools now being conducted at Pratt Institute, and asks coöperation in placing these men at the end of the course in March. This class consists of 19 men, each of whom is now working in the industry, and represents the following trades Machine work, machine drafting, carpentry, pattern making, electrical wiring, electrical maintenance and plumbing. Selected from among some sixty applicants by the director of the class in conference with practical men, there is every guarantee that they were from the outset unusually well qualified for teaching in the industrial school. The class is in charge of Wesley A. O'Leary, formerly director of the New Bedford Industrial School, who, on account of his experience, is well qualified for such work. Mr. Prosser says that "this course has aroused wide interest among teachers in this field as well as among others concerned with industrial education. It is very necessary that this experiment, carried on under the most favorable conditions and containing most of the factors essential to efficient training for service in this field, for the good of the movement, should meet with complete success. This can be done only by placing in service the men who are taking the training. If these men, after taking the training, should not find positions, it will be a serious obstacle to the further development of this work."

PERSONALS

John E. Sweet was given the degree of doctor of engineering at the midwinter meeting of the board of trustees of Syracuse University.

Henry R. Kent and Carl M. Vail, New York City, have formed a partnership to do a general engineering business under the firm name of Henry R. Kent & Co. The offices of the new company are at 141 Broadway.

F. W. De Mart has been appointed chief engineer of the power station of the Altoona & Logan Valley Electric Ry., Altoona, Penn., to succeed the late James Honor, a notice of whose death appeared in the Mar. 24 issue.

W. R. Haynie, the United States representative of the Carels-Diesel engine, sailed for Europe on the "Imperator," Mar. 21, to conclude arrangements for the manufacture of this type of engine in this country.

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Smoke Abatement in St. Paul—A report which has just been submitted by the smoke inspector of St. Paul, Minn., to the Health Department shows that the city is comparatively free from the smoke nuisance. This he attributes to the policy of his department to coöperate with railway companies and the owners of power plants in an effort to remedy improper conditions, rather than to institute prosecutions for violations of the city's anti-smoke ordinance.

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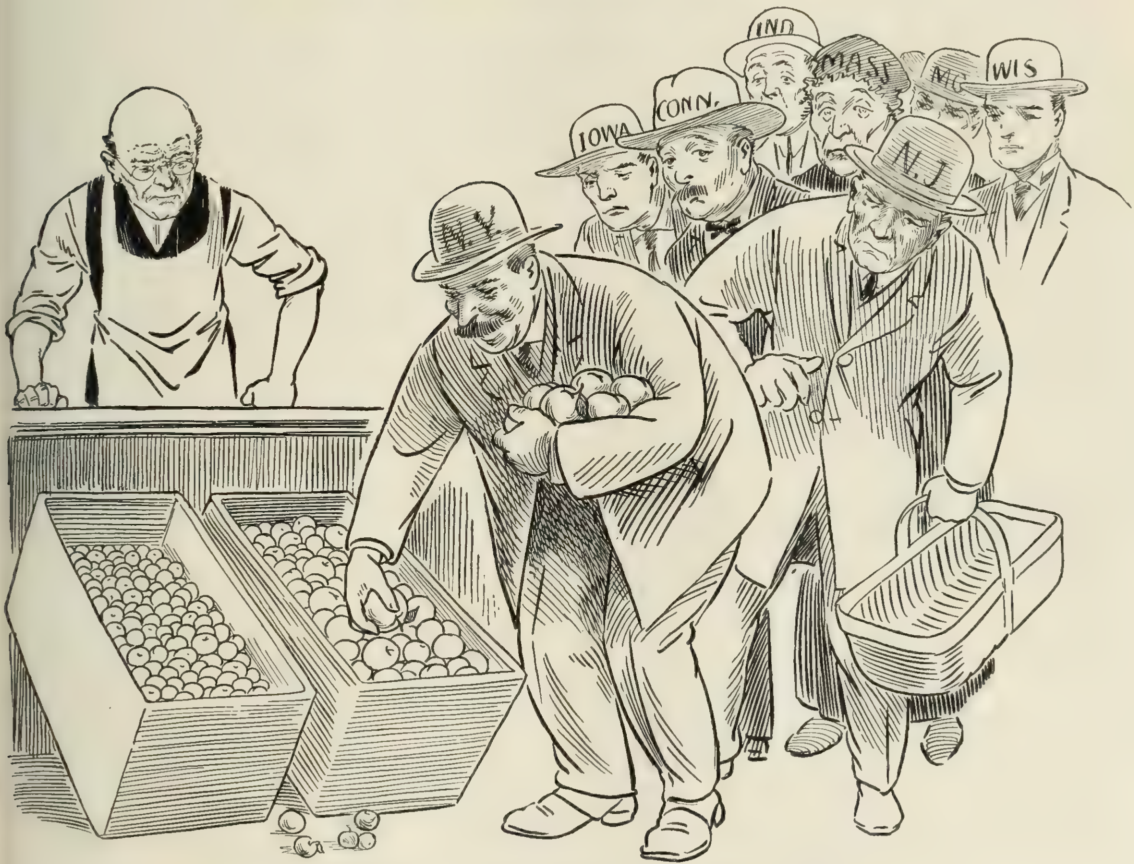
A Public-Service Commission for Illinois is to be appointed by Governor E. F. Dunne under a law recently passed, and the Illinois Society of Engineers and Surveyors has petitioned the governor to appoint as one member of the commission an engineer experienced in the design, construction and operation of public utilities. It is pointed out that this commission will have to adjust rates and deal with problems involving the operation of water-works, power plants, railways and other public utilities, and that technical knowledge of and experience with such engineering works are essential to enable the commission to act with efficiency to the state and equity to the corporations.

POWER

Vol. 39 NEW YORK, APRIL 7, 1911 No. 14

The Prudent Buyer



LOOK! HE'S PICKING OUT THE BEST ONES

IF these individuals went marketing for apples and were compelled to line up, each allowed to select the best ones, how bitterly those in the rear would complain.

But when they go marketing for coal!

Those who specify what they want get what they want, and pay for what they get. Those who don't are at the tail end of the line. They take what they get, but by no means always get what they pay for.

New York City saved over $200,000 on its coal bill the first year it bought by specification and slightly changed boiler room methods. By doing the same thing, New York State expects to save over $250,000 a year.

Who's next?

Powdered Coal in Boiler Furnaces

By William A. Evans

SYNOPSIS—Describes the results of numerous experiments in developing a boiler to successfully burn powdered coal, and tells why some methods of pulverized-fuel burning have failed. A checker-work wall, placed near the coal inlet to promote quick ignition, clogged with slag and quickly melted away. One experiment showed that the fuel and air absorbed more heat from the firebrick at the point of ignition than the walls could supply. To avoid this, the flame is caused to reverberate back on itself. Nearly all kinds of firebrick lining were tried with a total destruction of each within two hours.

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Experiments on Three Continents

The essential features of a powdered-fuel-burning furnace are suggested by a study of the many attempts made in comparison with a few successful installations. The experience of the designers of the Bettington boiler, especially adapted to powdered fuel, has been the experience of all up to the point of final failure. The developers of this boiler may be credited with carrying their experiment to a logical conclusion, whether this boiler is the only solution or whether it ever comes into common use.

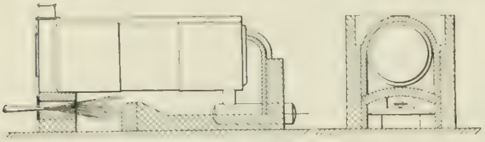


Fig. 1

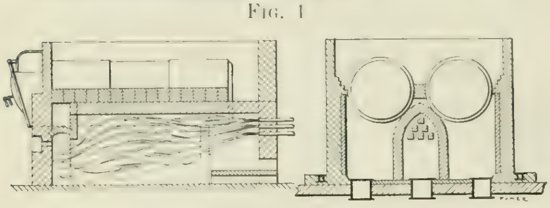


Fig. 2

Figs. 1 and 2. Old Ways of Feeding Powdered Coal to Tubular Boilers

The experiments were started over ten years ago, and have been conducted successively on three continents. They began in South Africa with a series of trials involving ten different settings on return-tubular and water-tube boilers. Four of these are shown in Figs. 1, 2, 3 and 4. The other six were but slightly different and showed practically the same results. The experiments were followed by others made by the same engineers with an installation (Fig. 5) at a central station in New York City. These experiments led directly to the design and building of the boiler shown in Fig. 6.

Point of Ignition Shifts

Fig. 1 shows the simplest arrangement under a return-tubular boiler. The grates are removed and the fuel is blown in through a flat rectangular tuyere. After ignition with an oil-soaked waste torch, the point of ignition gradually traveled forward away from the hot firebrick lining to a point where the flame was soon stifled by the cooling effect of the boiler surface. Instead of storing heat in the firebricks surrounding the fire, the blast of coal and air absorbed what little accumulated there during the starting period, and there was nothing to produce the initial ignition temperature for the incoming fuel. This action was accompanied by large deposits of dust and unburned coal in the tubes and under the boiler. During the short time when the flame was maintained, slag accumulated around the tuyere.

Influence of Flame on Slag

To provide greater radiating surface and larger settling space for the deposit of ash, two boilers were then arranged as in Fig. 2. Difficulties were again experienced in maintaining the flame and preventing the deposit of dust in the tubes. The flame seemed to blow itself out. Attempts were made with this setting to store the heat and obtain a regenerative effect by building a checker-work wall a few feet from the tuyere. This added another trouble as the slag clogged the checker-work wall; the wall frequently burned down. Enough heat was developed with this setting to show that slag would form wherever the flame reached and that provision must be made for its disposition. This was attempted in future trials by sloping the bottom of the furnace toward traps through which the slag was supposed to drain.

Air for Combustion Is Preheated

On account of the continued presence of dust in the tubes of the return-tubular boiler, it was decided to experiment with a water-tube boiler, from the tubes of which the dust could easily fall and settle. The setting, shown in Fig. 3, was arranged with long travel for the flame. Fuel was supposed to shower through the openings *A* and air to rise preheated between the inner and outer walls and mix with the falling powdered fuel. It was claimed that the fuel and air were not thoroughly mixed before entering the furnace, and, further, if combustion had been possible, heat would have caused the coal to coke in the passages *A* and the escaping coal tar would have clogged them completely.

Reverberating Flame Deemed Necessary

At this point the experimenters were convinced that the combustion of explosive mixtures in motion requires some igniting medium other than the radiation of heat from the brickwork alone. It was stated that the traveling fuel and air absorb more heat from the firebrick at the ignition than the flame is able to give in return. The result is that the brick at the point of ignition is continually cooling and gradually forcing the ignition forward into a hotter zone in the brickwork. This would seem to call for an auxiliary flame, always fixed close to the end of the fuel pipe or tuyere. It was provided for by making the flame reverberate back upon itself in its passage to the boiler, as in Fig. 4.

The Boiler a Low-Temperature Furnace

Good ignition was obtained in other furnaces with a direct flame and with no auxiliary igniting medium. Nevertheless, the rapid absorption of heat by boilers lends

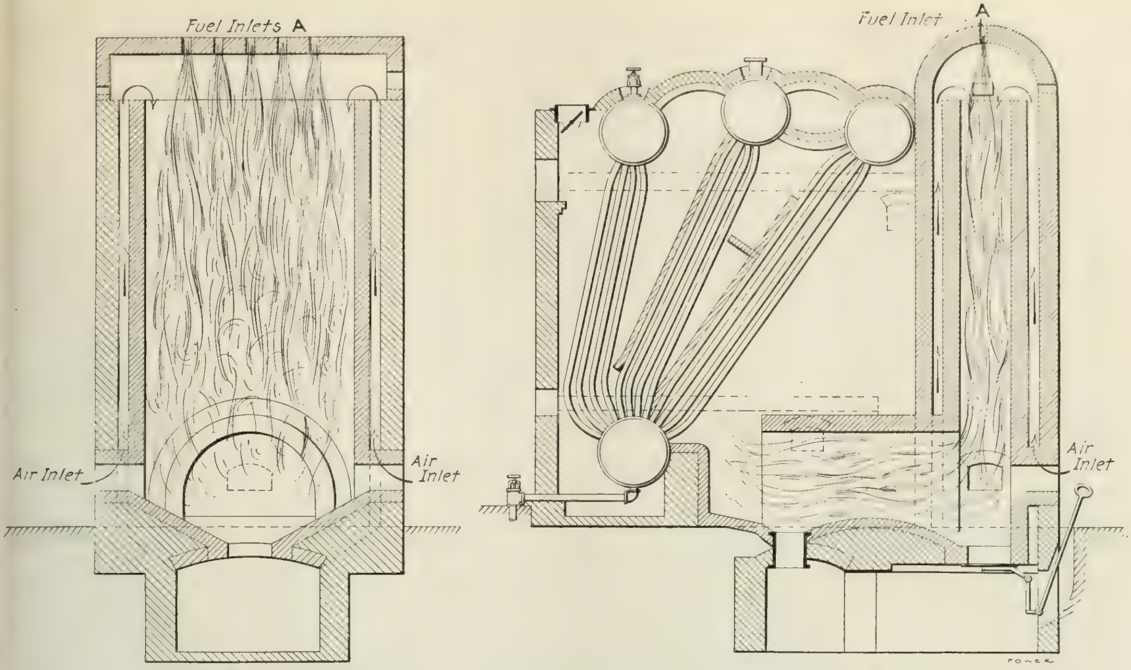


FIG. 3. THE FUEL INLETS PLUGGED WITH TAR AND COKE AND THIS PLAN FAILED

credence in this (first) practice, especially on boilers of low capacity, where only moderate heat is maintained in the combustion chamber. The boiler under ordinary ratings is a low-temperature furnace and powdered coal requires high temperature throughout for ignition and complete combustion. It is likely that trouble in maintaining ignition in such a furnace as Fig. 2 was due to coarse coal or an insufficient mixture of coal and air, either of which would be materially overcome by the reverberating flame. The arrangement, Fig. 4, was pronounced a success after trials of several different qualities of brick were tried. Magnesite lining stood up well, the flame was maintained, and combustion was complete. Slag formed on the sides of the vertical combustion chamber, trickled down the sides and then dropped and cooled in small lumps below the tuyere.

FIREBRICK DESTROYED IN TWO HOURS

It was probably a success under moderate boiler ratings, but when applied to boilers subjected to heavy overloads, such as prevail in central stations and in other practice, no brick could stand the intense heat. Fig. 5 shows the

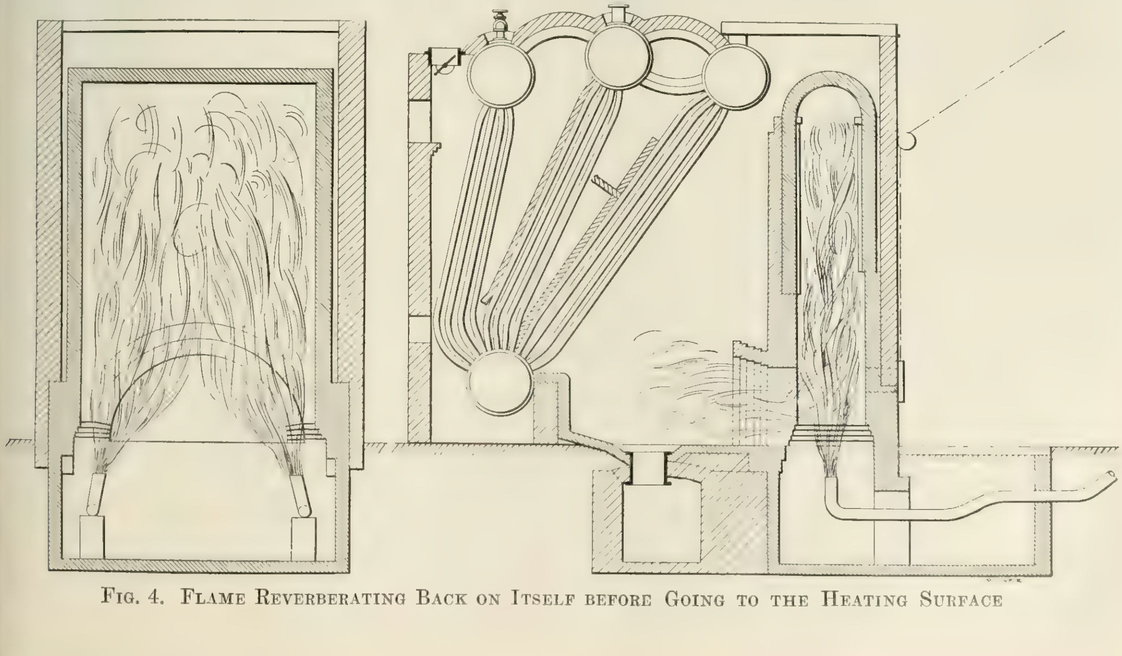


FIG. 4. FLAME REVERBERATING BACK ON ITSELF BEFORE GOING TO THE HEATING SURFACE

method of burning as applied to a water-tube boiler in the station mentioned above. Every conceivable quality and mixture of brick lining was tried. Nearly all were burned to destruction within two hours. Once it was possible to make a run of six hours by careful tempering of the flame and running the boiler at about rated capacity; even then the brickwork tumbled in. The boiler showed a fair evaporation though much unburned coal was found under the back end. A hard, glassy coating formed on the lower tubes next to the flames. This was probably due to the sticky nature of the hot ash together with the coal-tar products escaping and only partly burning on striking the tubes.

PART OF SETTING IS WATER COOLED

The final step was to cool the brick lining of the combustion chamber. This was accomplished by using special bricks through which passed water tubes connected into the path of the boiler circulation. This feature was incorporated in the special boiler, Fig. 6, known as the Bettington. In it the fuel enters the furnace vertically and upward through a water-cooled tuyere and is ignited by the flame reverberating back upon itself. The hot gases pass up around the water tubes in the annular space between the combustion chamber and the outside wall of the boiler. Even with this method of cooling, the brickwork melts away at the hottest part of the flame, leaving only a thickness of ¼ to ⅜ in. protecting the tubes. The whole inside or fire surface of the brick fuses into a solid mass. It will be noted that in the specially designed boiler there are no places for the deposit of ash within the influence of the flame. This does away with the possibility of the fusing of the ash by the heat, on or in places where it should not remain and from which it would be difficult to remove it.

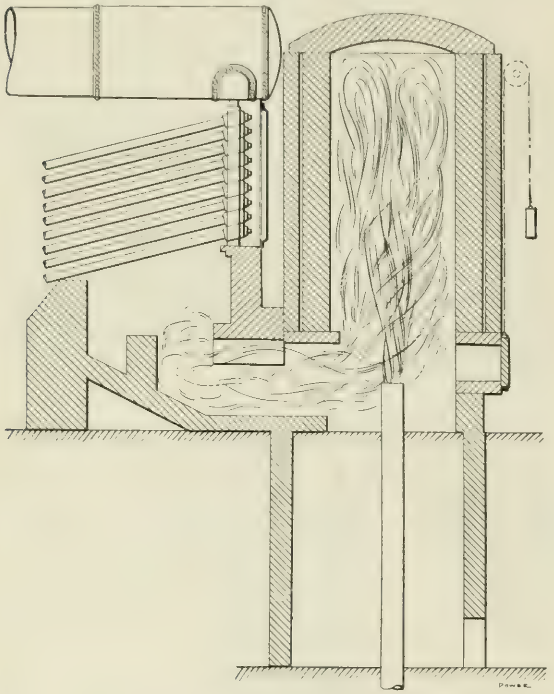


FIG. 5. POWDERED-COAL FURNACE AS APPLIED TO B. & W. BOILER IN NEW YORK STATION

HANDLING OF SLAG A PROBLEM

It was found that the sloping floors of the furnace did not ameliorate the slag difficulty. The slag would not flow and to get it out after cooling involved considerable labor and the destruction of the brickwork. In the Bettington boiler the only place where ash can settle is directly below the combustion chamber. Here the ash is not in contact with the flame, and is at a temperature low enough to prevent the separate drops of slag from sticking to one another.

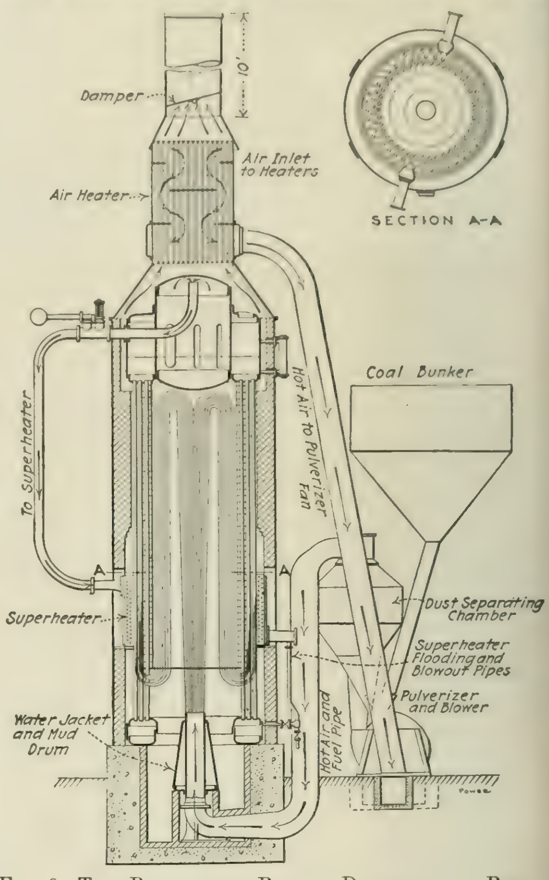


FIG. 6. THE BETTINGTON BOILER, DESIGNED FOR BURNING POWDERED COAL

The boiler is reported to be a success; that is, it "stands up" well and has few of the operating difficulties that have prevented others from even approaching the economies in fuel and operating cost that have been so definitely demonstrated possible with powdered coal in other types of industrial furnaces. It has shown a thermal efficiency of 80 per cent. on very poor coal and several thousand horsepower is now operating. The 80 per cent. efficiency with 4 per cent. deduction for power for pulverizing is not so remarkable, but the boiler gives one solution of the problem of combustion of powdered coal and its design is possible of improvement that may make the thermal efficiency more attractive.

Vacuum Ash-Removal System

A simple system for the removal of ashes which has been in successful operation in a number of plants is shown in the accompanying illustration. As manufactured by the Girtanner Daviess Engineering Co., of St. Louis, Mo., the system is made up of 6- or 8-in. chill cast-iron pipe of suitable lengths and 1 in. thick. The pipe is joined by tongue-and-groove cast flanges which are fitted with a special packing and bolted to make an air-tight joint. When it is necessary to make a turn an elbow of 4-ft. radius or greater is used. The elbow is made up in sections about 18 in. long. These sections are split, and the outer piece, which takes up nearly one-half of the circumference of the pipe, is made extra heavy to resist the wear at this point. At the center it is 2 in. thick. As indicated in the illustration the two parts are bolted together, so that the outer piece may be easily renewed.

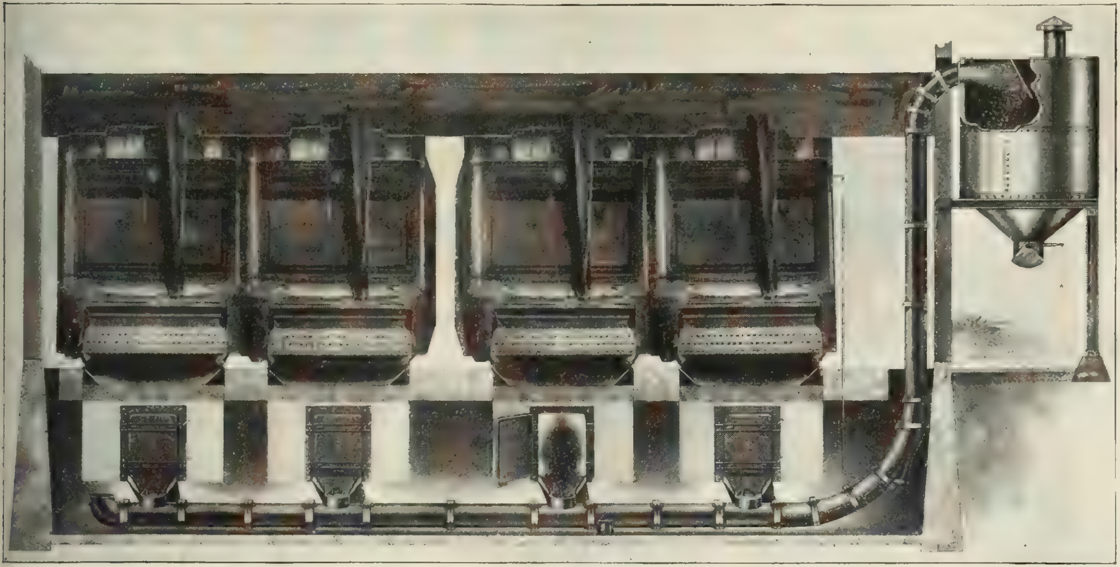
Hoppers for receiving the ashes are located at points opposite the ashpits of the boilers. The opening in the hopper is round and tapers toward the bottom to insure a tight-fitting lid. The bottom of the lid conforms to the diameter of the pipe so that when it is set in position there is no interference with the flow of air and ashes.

The ashes are moved through the conveyor by steam from a nozzle pointing in the direction of flow. The nozzle is located between the last hopper and the point of delivery, and is either ½ or ⅝ in. in diameter, depending on the distance and amount of ashes to be removed. Turning on the steam creates a vacuum of 16 to 25 oz. and induces a flow of air through the pipe. The ashes are fed into this stream of air at the rate of about 200 lb. per min. and may be discharged into a car, an ash bunker or wherever desired. In one of the installations now working, ashes are being conveyed over 300 ft. and in another elevated 97 ft.

The cost for steam is the principal operating expense. In a recent test on a system using an 8-in. pipe and a ⅝-in. nozzle, to which boiler pressure of 110 lb. gage was supplied, 1850 lb. of steam per hour was required to handle seven tons of ashes. At 20c. per 1000 lb. for steam, the cost of removal per ton of ash would amount to

$$\frac{1.85 \times 20}{7} = 5.29c.$$

With the ½-in. nozzle less steam would be required but the capacity would be less, so that the cost would be about the same as for the larger nozzle. Raising the pressure in either case would increase the volume of steam discharged and also the capacity of the system, so that it is fair to assume an average charge of 5 to 6c. per ton of ash.



Application of Vacuum Ash-Handling System to a Battery of Boilers

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Rapid Chimney Building—A St. Louis construction firm recently built a chimney 85 ft. high and 3 ft. inside diameter, in seven working days. It was of reinforced-tile concrete, with a reinforced-concrete foundation, and was put in service 16 days after the receipt of the order. During its construction the heaviest snowfall in ten years occurred. At no time was it warmer than 20 deg. F., when work was started in the morning. The sand was heated before mixing and the tile was heated before placing. Fires were kept in the chimney constantly with all openings closed.

⁂

A Big Coal Bill—The Commonwealth Edison Co. burns about 5000 tons of coal daily and its coal bill is about $2,000,000 a year. About 250,000 tons is kept in reserve in or near Chicago at all times. Nearly all of this is of egg or lump size, as the danger of fire from spontaneous combustion is less with the larger sizes. Thermometers are placed in all coal piles and weekly records of temperatures are taken. It is frequently found necessary to move piles of screenings of mine-run coal to prevent or fight fires.

Calibration of Indicator Springs

By S. K. Baldwin

SYNOPSIS—Full instructions for testing inside and outside springs and an accurate method of locating the atmospheric line.

Indicator results are supposed to be correct to within 2 to 5 per cent., but as the spring is often as much as 2 per cent. out, this is an error right at the start which may make a further discrepancy. It seems almost needless to say that the link work of an indicator must be in good shape, yet little attention is paid to this point. Some indicators have so many links and loose joints that there is a sixteenth-inch pencil movement before the spring is moved. And again, so little care is taken of the piston that perfectly absurd results are obtained, such as the intake line of a gas engine or compressor above the atmospheric line. At pressures close to atmosphere the indicator spring is practically in equilibrium, and a small friction force will hold the pencil quite far away from the position corresponding to the pressure. This same friction near the equilibrium point will displace the atmospheric line, especially with a "soft" spring, and this is most important in both gas engine and air cylinders.

To obviate this piston friction, it is necessary to have the parts in such good adjustment that, while looseness is all but eliminated, the piston and its rod will drop down through the indicator cylinder by gravity, the spring having been removed. After this trial, connect up the link work, but without the spring, and ascertain whether or not gravity will cause the entire system to drop. Any sticking during the stroke will show up and the cause should be removed.

The next test is to close the bottom of the indicator cylinder with the finger and if there is proper piston tightness, this closure should prevent the piston from dropping because of the air trapped inside. Removal of the finger and escape of the air should allow the piston to drop at once by its own weight.

With the indicator in first-class condition, the next step is to calibrate the spring by subjecting the indicator to a series of constant pressures whose values are exactly known, and to rotate the indicator drum so as to draw horizontal lines on the paper corresponding to these pressures. The heights of these lines are measured from the atmospheric line, and then the scale is determined by dividing the true pressure by this height. For instance, suppose the pressure is 120 lb. per sq.in., and the line drawn is exactly 1.5 in. above the atmospheric line, then the scale of the spring is

$$120 \div 1.5 = 80 \textit{ lb. per in.}$$

of vertical movement. If the height above the atmospheric line had been 1.51 in., the scale of the spring would be

$$120 \div 1.51 = 79.5 \textit{ lb. per in.}$$

This would introduce an error of about 0.6 of 1 per cent. in the calculation, if the maker's stamping of 80 lb. had been assumed to be correct. There are, no doubt other factors of a test more incorrect than this, but if such an error can be at once eliminated by proper calibration, it should by all means, be done. It should be remembered that such errors may accumulate, instead of neutralizing one another, and thus affect the final test result to a far greater extent.

There are various ways of applying the known pressures to the indicator. One way is to use air or steam, controlled preferably by a needle valve, and providing an adjustable leak in the system for the escape of the air or steam. This leak is essential as otherwise it will be found impossible to control the pressure. Of course, the applied pressures must be known, and a way to do this is to use a good pressure gage which has been carefully calibrated by a deadweight tester. A curve is plotted, showing the exact reading of the gage for every known pressure within its range. From this curve the true pressure exerted for any gage reading may be read and applied to the corresponding line on the calibration diagram drawn by the indicator.

As practically none but the most expensive test gages will read exactly alike in both directions of travel, this limits the usefulness of steam or air calibration to those cases where it is absolutely necessary. The method is long drawn out and involves the calibration of the gage and the drawing of its curve before applying the true pressures to the indicator lines.

When an inside-spring indicator is used, this method allows a spring temperature during the test, which will be approximately that under which the spring will be used. Inside spring indicators are almost invariably much stiffer cold than hot, so that the scale will be different.

As most modern indicators are of the outside-spring type, the process of calibration is simplified. I have found the use of the deadweight tester, with oil, to be the handiest and by far the most accurate method. Of course, the indicator piston must be reasonably tight, or excessive oil leakage will give trouble. Some form of pump for supplying more oil to replace the inevitable piston leakage should be provided. At best, it is a rather unpleasant job, as the operator is likely to become pretty well oiled during the process.

One objection to the use of oil is that it takes an appreciable time for the indicator piston to come to its corresponding point. It is imperative that the work be done slowly, allowing plenty of time for all parts to come to equilibrium for each pressure. The deadweight plunger should, of course, be rotated during this time, and the indicator gently rapped with a piece of wood to assist in neutralizing the friction. More uniform and consistent results are obtained if the full pressure is gradually applied to the indicator and then gradually removed again before starting to draw any lines. This lubricates the piston and gets all parts into working condition.

As intimated before, the great trouble in all these calibration methods is to locate the atmospheric line. It is impossible to do it when the indicator is full of oil. A trial will show a displacement of $\frac{1}{32}$ to $\frac{1}{16}$ in., depending upon the stiffness of the spring. This is because the oil is too viscous and allows no air leaks, and with the spring under no tension at all, as at atmospheric pressure, only a small friction force will displace it materially. For this reason, it is good practice, first to give the preliminary loading, then to remove it and take the indicator from its connections, allowing all the oil to run out of the cylinder from both below and above the piston. Then tap the indicator with a piece of wood, keeping it in the hand right side up; finally draw the atmospheric line with the indicator still in the hand and perfectly free from all restraint. Then attach the indicator to the deadweight tester, apply the load in at least five steps and draw a line for each step, observing the precautions of time allowance and vibration, being also careful not to touch any of the link work with anything.

With such care as this I have repeatedly obtained lines which were identically located for both increasing and decreasing pressures. Always increase the pressures in steps to the maximum and then decrease them in the same steps, and if the corresponding lines vary 0.02 in. for any one pressure, discard the test. A less variation than this may be allowed to stand and the average position be taken for the true one.

All this precaution may seem excessive, but unless the calibration is made properly it would be better to take the maker's stamping as correct, for it will be nearer the truth than a so called "rough calibration."

It is customary in working up one of these spring-calibration diagrams to measure all heights from the atmospheric line. From this very fact, it is obvious that the location of this line is by far the most important operation. If the pressure lines vary a little, an average will give the truth, but if the atmospheric line varies, every result of all the different pressures is wrong and no average will make it right.

It is easy to tell a displaced atmospheric line, because it will give a scale which either increases or decreases as the spring is compressed. If the atmospheric line is correctly located, the scale of the spring will be found practically constant throughout its range. To eliminate the difficult process of properly locating the atmospheric line, the writer has adopted the method of measuring all the distances from line to line, and taking the average of these. It is not at all practical to base calculations on distances of less than ½ in., because the slightest error of measurement is such a large proportion of the whole distance that relatively large errors can be introduced. My procedure is to measure from each pressure line to every other pressure line, neglecting all spacings of less than ½ in. In this way, scale calculations of great consistency for the entire range of a spring have been obtained. All dependence upon the erratic atmospheric line is removed with its attendant errors.

To illustrate, Fig. 1 shows a calibration diagram for a 60-lb. spring and Fig. 2 for a 200-lb. spring. These diagrams have been divided off into lettered sections, each section corresponding to measurements from some one pressure line as a base. For instance, in Fig. 1, section *A* shows measurements to all pressures from atmosphere; section *B* from the 25-lb. line, etc. Distances less than ½ in. have not been included in the averages. In section *A*, where all measurements are from what was obtained as the atmospheric line, the spring scale appears to decrease as the pressure increases. From atmosphere to 40 lb., the measured distance is 0.65 in., giving a scale of

40 ÷ 0.65 = 61.6 *lb. per in.*

From atmosphere to 55 lb., the scale is 60.8, and so on to 110 lb., where the scale appears to be reduced to 60 lb. The 25-lb. line has been neglected, because it is less than ½ in. from the atmospheric line, but calculation from its actual measurement runs the scale up to 62.5 lb. at this point. An average of all the calculated scales measured from atmosphere, with the exception of the 25-lb. line, gives an apparent scale of 60.6 lb. per in.

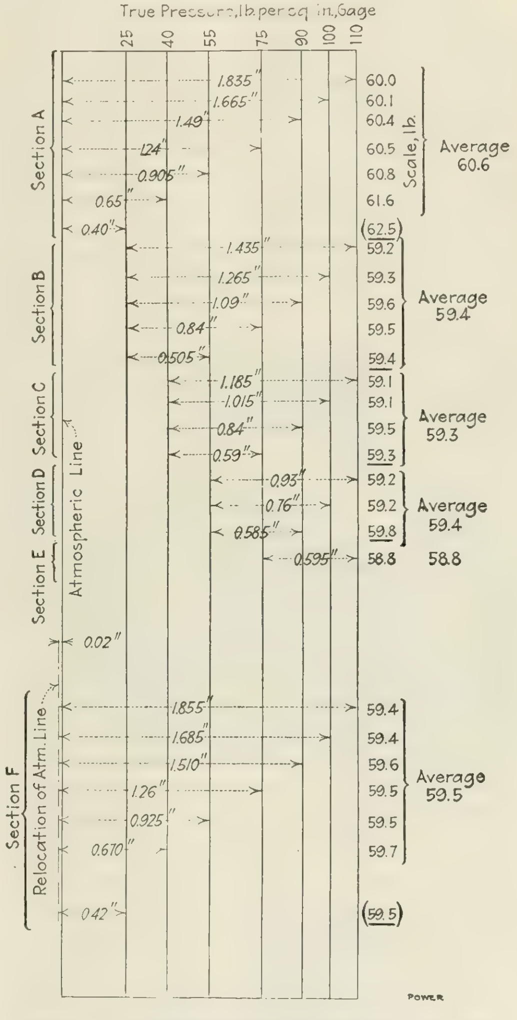

Fig. 1. Calibration Diagram for a 60-Lb. Indicator Spring

Measuring from the other lines gives scales whose averages are: Section *B*, from 25-lb. line, 59.4 lb.; section *C*, from 40-lb. line, 59.4 lb.; section *E*, from 75-lb. line, 58.8 lb. It will be noticed that in each section, measuring from any one pressure line (except section *A* from atmosphere) there is no apparent increase or decrease of scale. The average of sections *B*, *C*, *D* and *E* is 59.3 lb. per in. This is a total average of all values;

not an average of averages, as this last would give equal prominence to section *E*, with only one figure; whereas it should have a relative weight of one-thirteenth of the entire thirteen numbers.

In section *F*, Fig. 1, the atmospheric line has been moved 0.02 in. downward, assuming that the sticking of the indicator piston when the spring was thus practically free of compression, resulted in this much displacement of the pencil. This is well within practical probabilities. Moving the atmospheric line down this distance results in adding 0.02 in. to each of the measurements in section *A*, these now being as in section *F*. Calculation from these new measurements from the relocated atmospheric line gives a scale whose average value is 59.5, and which shows practically a constant value throughout the range. Even the 25-lb. line gives this same value for this relocated atmospheric line. Also, the average value of section *F* is in almost perfect accord with sections *B*, *C*, *D* and *E*.

It may well be assumed that in this case the atmospheric line was misplaced 0.02 in. by sticking, and the average scale obtained from measurements from all sections, except section *A*, is practically 59.4 lb. per in. This again is an average of all 19 numbers, thus giving equal weight to each separate measurement. Comparing this value of the most probable scale of this spring with that which would be obtained from an average of section A, from the original atmospheric line, or 60.6, it will be found that 60.6 is just 2 per cent. greater than 59.4. Thus it is plain that a 0.02-in. misplacement of the atmospheric line in calibration renders the scale and all horsepower results based on that scale, wrong from the very beginning by 2 per cent. In this case it would have produced an error of only 1 per cent., or half the error, if the experiment had assumed the maker's marking to be correct at 60 lb. It must be remembered that these errors of the indicator spring are carried on to the figures for steam consumption per indicated horsepower-hour, mechanical efficiency and any other determinations based on the indicated horsepower.

In Fig. 2, is shown a calibration diagram for a spring marked 200 lb. per in. Section *A* shows measurements from the atmospheric line, resulting in an average scale of 196.4, the scale appearing to increase rapidly with the pressure, with the single exception of the distance measured to the 250-lb. line. The other sections show measurements from the various other pressure lines, neglecting, as before, all distances less than ½ in. Some of these shorter distances are given in brackets, although not included in the averages. The total average of all the seven values over half inch, of sections *B*, *C* and *D* is 199.1 per in., which is 2.7 lb. greater than the apparent scale shown by measurement from the atmospheric line.

It was next ascertained if a relocation of the atmospheric line would help, and a new position 0.01 in. above the original line was selected, as shown in section *E*. The distances measured in section *E* are all 0.01 in. shorter than those in section *A*, and the resulting average scale in section *E*, which is remarkably uniform, is 198.6 lb. per in. Taking an average of all the thirteen separate values in sections *B*, *C*, *D* and *E* gives a final average of 198.9 lb. per in., which probably is nearest the truth. This is only 1.1 less that the maker's marking instead of 3.6 lb. less. The apparent correction by atmospheric line measurement would have been about 1¾ per cent., whereas the more probably true correction is one of only about ½ of 1 per cent. Again, in this case, the maker's marking was nearer the truth than an erroneous, although really carefully made calibration. All this is due to a misplacement of the atmospheric line of only 0.01 in.

No doubt the objection will be raised that it is impossible to make such close measurements of pencil lines drawn by an indicator. Judging from many of the wide lined and "smudgy" indicator diagrams the objection is well taken. However, such accurate work as this requires a certain amount of skill, a sharp pencil point and a light pencil pressure.

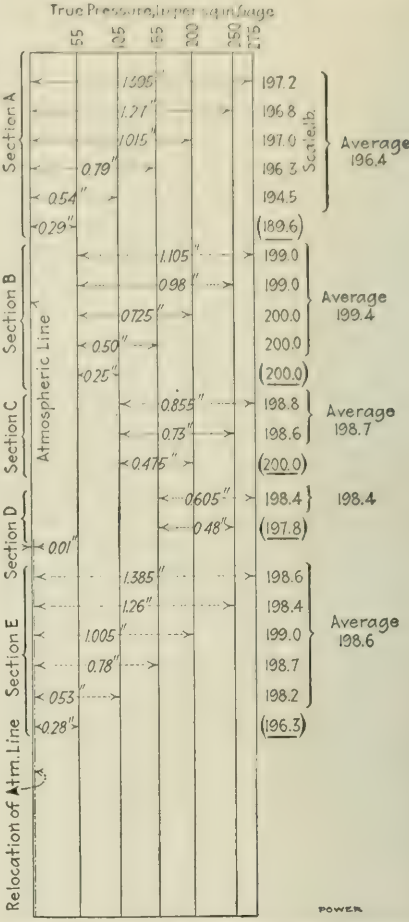

Fig. 2. Diagram for a 200-Lb. Spring

This error is quite comparable to those of cord stretch and drum inertia which have recently been given considerable attention. It is perfectly possible, with a scale of 50 per in. to read to the nearest half hundredth, or 0.005 in. Of course, this requires estimation to ¼ of a division, but a little skill makes this easy. If preferred, a 100 scale may be used, reading to half a division, but a magnifying glass would be required, so that the 50 scale is easier to handle. No attempt is made to measure closer than the nearest half hundredth of an inch, or 0.005 in., as anything closer than this is out of the question, both as to possibility and necessity.

Multi-Stage "Economy" Steam Turbine

The steam turbines of multi-pressure type, Fig. 1, built by the Kerr Turbine Co., Wellsville, N. Y., are rated from 700 to 1800 hp. Turbines of smaller capacities up to 700 hp. were built by the company before the larger sizes were developed. These earlier designs embodied buckets of the Pelton type, which could not be developed to desired efficiencies. These buckets were, therefore, supplanted by vanes and blades, Fig. 2, producing parallel flow of steam in the direction of the turbine shaft and capable of better water rates.

Figs. 3 and 4 show the horizontally split shell employed in the larger machines, and how the rotor may be inspected or removed without breaking the steam connections. When the turbine cover is removed, each wheel is exposed down to the carbon packing on the shaft, there being no diaphragms left between the stages, as these are integral with the casing and lift off with it. The guide vanes or steam nozzles are cast in the diaphragms. Fig. 5 shows a section through a turbine of 500-750 kw. capacity.

Steam is expanded in a number of stages or steps, and the pressure drop at each set of nozzles is comparatively small, with correspondingly low steam velocity, the latter, it is said, rarely over 1000 ft. per min. The leakage area from stage to stage is also small, being confined to the annular space where the shaft goes through the pressure chamber walls or diaphragms.

Leakage from stage to stage at the shaft is prevented by floating carbon packing rings, held in the diaphragms and in the high- and low-pressure ends with cover plates, which are so arranged that they can move in any direction, in case the turbine shaft should vibrate with a large dose of water. The steam pressure, being higher on one side of the diaphragm than on the other, keeps the carbon rings tight against ground seats.

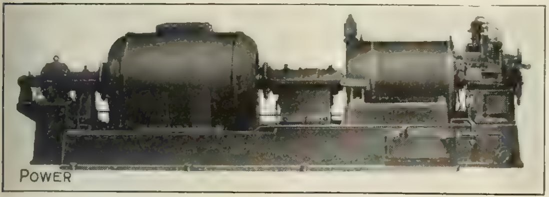

Fig. 1. Kerr Multi-Pressure Turbine

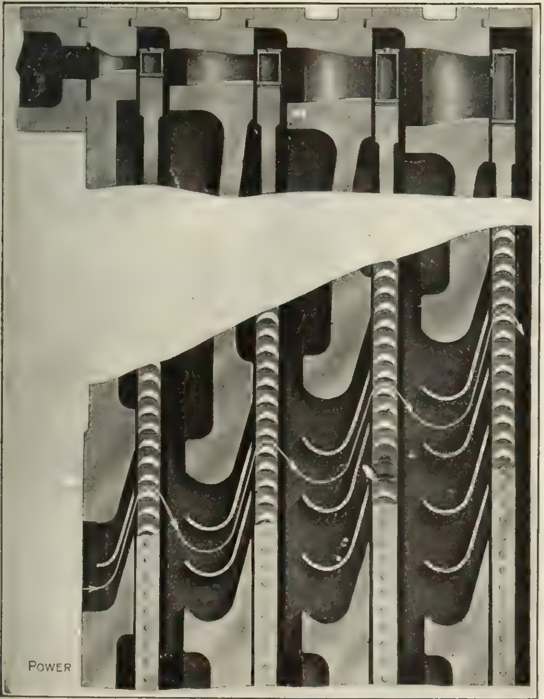

Fig. 2. Showing Operating Principle of the Turbine

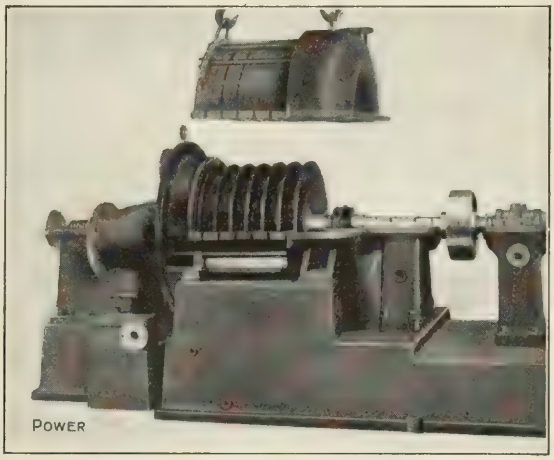

Fig. 3. Showing Horizontally Split Casing and Pedestal Bearings

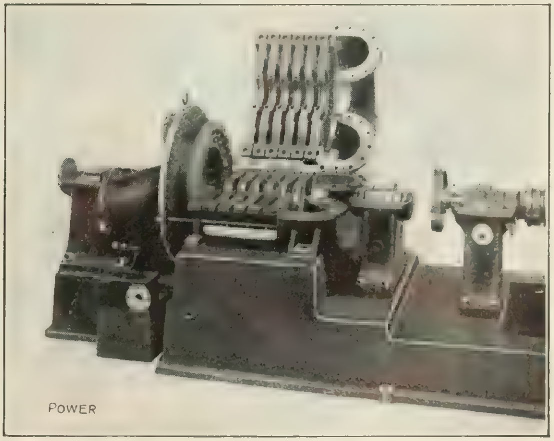

Fig. 4. Turbine with Rotor Removed

The large clearance permissible at the buckets is utilized, as shown in Fig. 6, to protect the buckets from stripping, and the hard, tough original skin left on the drop-forged buckets resists the minimized tendency toward erosion. The method of riveting the buckets into the wheels and shrouding is shown in Fig. 7.

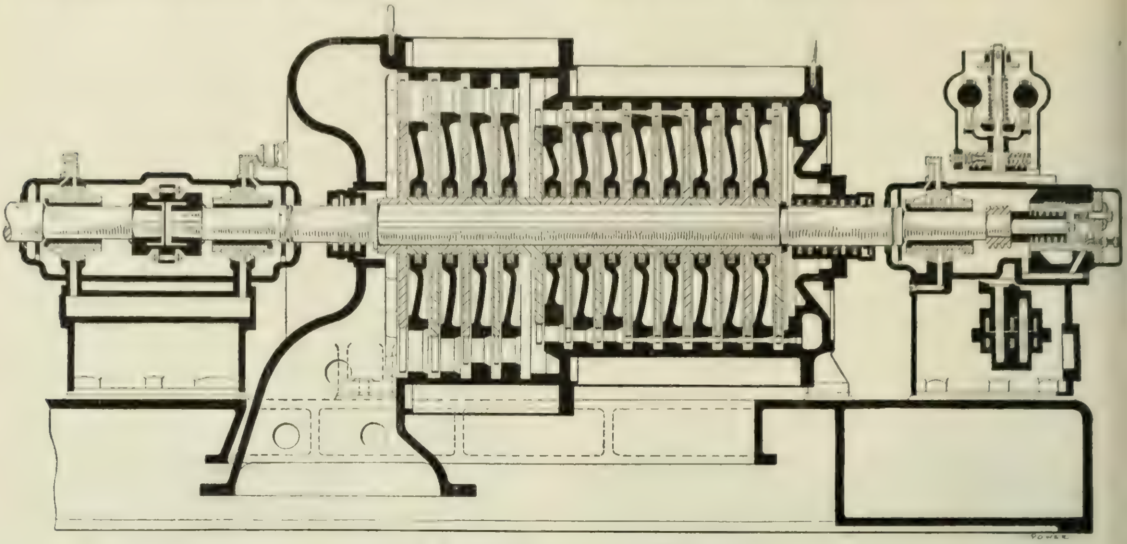

Fig. 5. Section through Turbine

A small turbine-driven centrifugal pump, with the impeller submerged in the oil reservoir, forces the oil to the bearings before the machine is turned over. After starting, a spur-geared oil pump, directly connected to the governor spindle, forces oil under 6 lb. pressure to every bearing. The oil drains back by gravity to a large reservoir in the bedplate, where it is strained and water cooled. An independent emergency governor, operating a quick-closing throttle valve, which is moved by oil under 30 lb. pressure, is used.

The bearings are of heavy-pedestal type and ring oiled. A marine-type thrust bearing adjustable and easily replaced maintains the rotor in its proper position. The unit is mounted on a heavy cast-iron bedplate. The lagging outside the turbine cylinder is covered with enameled sheet iron which protects the insulation and gives a finished appearance to the machine.

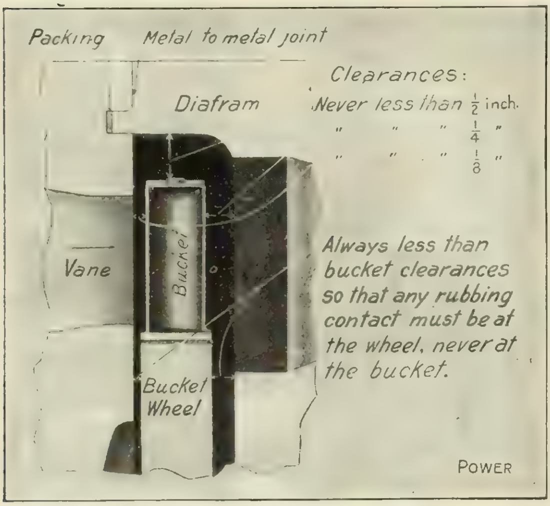

Fig. 6. Showing Clearance of Buckets

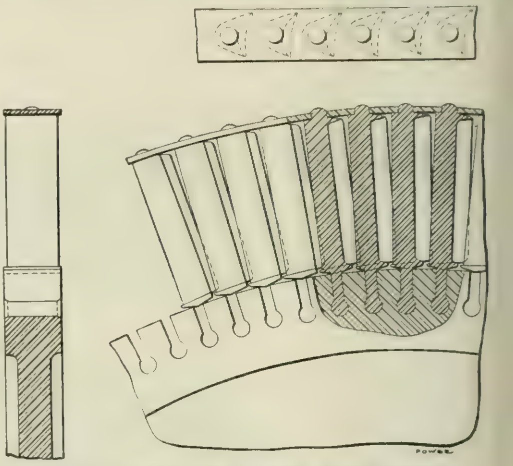

Fig. 7. How the Buckets Are Secured

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Panama Electrical Engineers Form Section—The American Institute of Electrical Engineers has authorized the formation of a Panama section. There are some thirty members of the Institute now on the Isthmus.

⁂

Italian Thirteen-Million-Dollar Water-Power Plant—The Italian Parliament has passed an act authorizing the construction of a 150,000-hp. hydroelectric development in Calabria, in southern Italy. The contemplated construction will require the erection on a grand scale of three dams at an estimated cost of some $13,000,000. In the aggregate it is expected to supply about 150,000 hp. for traction, illumination, and the development of industries, not only in Calabria, but also in Apulia and throughout southern Italy in general. Energy will also be employed on a large scale for irrigation purposes—"Electrical World."

Computing Charts for Closed Heaters

By W. J. Demorest

SYNOPSIS—By means of charts, when drawn to large scale, the required distribution of heat between primary and secondary heaters and also the coal saving and cost of heaters may readily be obtained without resorting to long arithmetical calculations for each set of conditions.

⁂

In the February, 1902, issue of Power, there appeared an article by C. G. Robbins on "Feed Water Heaters in Condensing Plants." It is the purpose of the present article to show how charts may be prepared to obtain, for given conditions, the results of computations, such as pointed out by Mr. Robbins' article, without employing tedious arithmetical computations; and also to give the coal-pile saving and the initial cost for the heater installations.

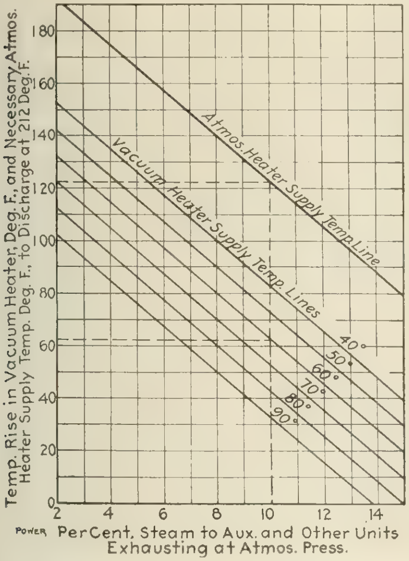

Fig. 1. Temperature Rise in Vacuum Heater and Necessary Initial Temperature of Water for Atmospheric Heater to Discharge at 212 Deg.

Fig. 1 is to aid in determining the proper distribution of the heating process between atmospheric and vacuum heaters. The latter are usually known as primary heaters. On occasions the condenser itself has been used as the primary heater, the circulating water taking the heat from the steam and passing on to the atmospheric heater. The horizontal scale gives percentages of the total steam generated by the boilers used by auxiliaries or any units exhausting at atmospheric pressure. Following any vertical line up to a single heavy diagonal line running across the chart and over to the scale on the left-hand side, gives the temperature at which the atmospheric heater must receive the water if it is to be discharged at 210 deg. F. If the water does not drop in temperature in passing from the vacuum heater to the atmospheric heater, this will also be the vacuum-heater discharge temperature. In computing the values for this line, it was assumed that 90 per cent. of the steam exhausted at atmosphere was condensed in the heater, each pound condensed giving 970.4 B.t.u. to the feed water. On the same chart is plotted vacuum-heater temperature rise with various feed-water supply temperatures. This is obtained by subtracting the temperature of the feed-water supply from the temperature of the supply to the atmospheric heater.

Fig. 2 is for computing the heating surface required to obtain different heating conditions, and also to find the cost of the heater. The curves in the lower left-hand corner are plotted between final water temperature and mean temperature difference,* several curves being drawn for various rises in temperature.

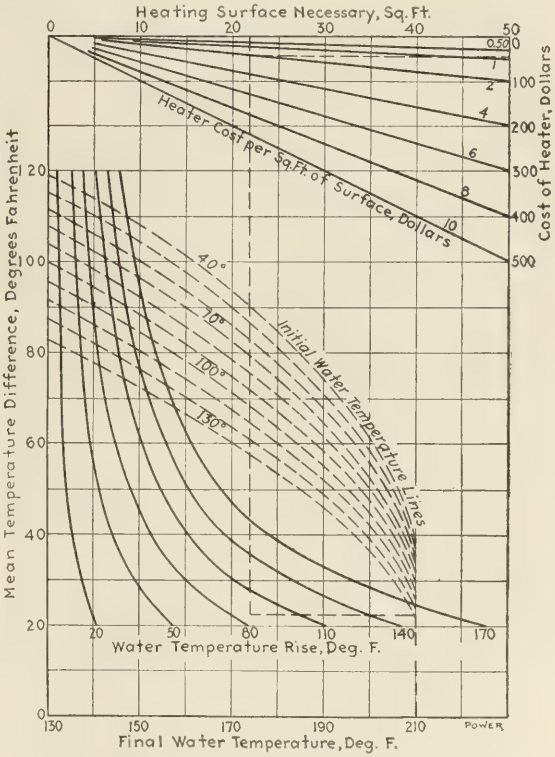

Fig. 2. Heating Surface Required and Cost of Heater

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*The formula used for figuring the mean temperature difference was:

$$M = \frac{I - F}{\text{Nap log } \frac{I}{F}}$$

where

M = Mean temperature difference;
I = Temperature difference between steam and water entering heater;
F = Temperature difference between steam and water leaving heater.

The dotted curves immediately above are plotted between mean temperature difference and square feet of heating surface necessary when heating 1000 lb. of water per hour, the coefficient of heat transfer being 180 B.t.u. per hr. per sq.ft. of heating surface per degree mean temperature difference. This is as high as can be counted on continually when the tubes are liable to get coated with oil, although values of this constant of over 300 would represent conditions in new heaters, when the tubes are clean. The units in which the coefficient is expressed explain how the computations were made for these curves. The set of curves at the top of the chart is plotted between square feet of heating surface and cost of heater. The values for these curves were obtained by multiplying the square feet of surface by the cost of surface per square foot.

Fig. 3 can be used for computing the coal-pile saving in a plant by a feed-water heater installation. All curves on this chart give values corresponding to a water consumption, at rated load, of 1000 lb. per hr. In the lower right-hand corner is plotted a series of curves showing the relation between hourly heat returned to the boilers by heating the feed water, and corresponding coal heat saved for various boiler efficiencies. The coal-heat saving is obtained by dividing the water-heat saving by the boiler efficiency. Then for various heat-unit contents per pound of coal, it is possible by division to get the hourly coal saving in pounds, which is the basis for the other set of curves at the bottom of the chart. Multiplying the hourly coal saving in pounds by the cost of the coal in cents per pound, gives the hourly coal-pile saving in cents. In this way the values were figured for the full lines at the top of the chart. Ten cents per ton was added to the cost of the coal for handling. Now multiplying the hourly saving by 8760 (hours per year) and by the load factor, gives the net yearly saving in coal, shown by the dotted lines at the top of the chart. It must be remembered that this gives the coal saving only. To get the total net saving it is necessary to add the saving due to less boiler capacity being required and subtract the cost of interest, depreciation, labor, etc., incident to operating the heater. These elements cannot be readily plotted so as to be of any use.

To fully demonstrate the method of using the charts the following problem is traced on them. Assume 5000 lb. of steam generated per hour, 60 deg. F. feed-water supply, 10 per cent. of steam to auxiliaries, vacuum heater cost $4 per sq.ft., atmospheric heater cost $2 per sq.ft., 70 per cent. boiler efficiency, 13,000 B.t.u. per lb. of coal, coal cost $3 per ton, and 30 per cent. load factor. In Fig. 1 read up from 10 per cent. to the upper heavy line and to the left to find that the atmospheric heater must be supplied with water at 122.5 deg. F. to discharge it at 210 deg. F. Reading to the left from the 60-deg. water-supply temperature line, gives 62.5 deg. as the required temperature rise in the vacuum heater. Assume no cooling of the water between the heaters. Passing to Fig. 2 read up from 210 deg. F. final water temperature of the atmospheric heater to 122.5 deg. F. initial temperature, then over to 87.5 deg. temperature rise and up to the heating-surface scale, which shows that 21.8 sq.ft. of surface will be needed per 1000 lb. of steam per hour. It would then require

$$5 \times 21.8 = 109 \text{ sq.ft.}$$

for the 5000 lb. per hr. Reading across from the line representing a heater cost of $2 per sq.ft., the cost of the required heater is found to be

$$\$44 \times 5 = \$220$$

In Fig. 3, which may be used for any device which returns heat to the boilers, read up from 87,500 B.t.u. of heat returned to the boilers per hour to the 70 per cent. boiler-efficiency line, to the left to the line for 13,000 B.t.u. per lb. of coal, up to the line representing a coal cost of $3 per ton, to the right as far as the line for 30 per cent. load factor, and down to the yearly coal-pile saving, reading $38. Then the total yearly coal-pile saving by a heater under the assumed conditions of the example would be

$$5 \times \$38 = \$190.$$

The fine dotted lines on the charts show the paths followed in solving this problem. The cost and yearly coal-pile saving for the vacuum heater might be solved in a similar manner, but are not traced on charts 2 and 3 because of the complication of lines which would result.

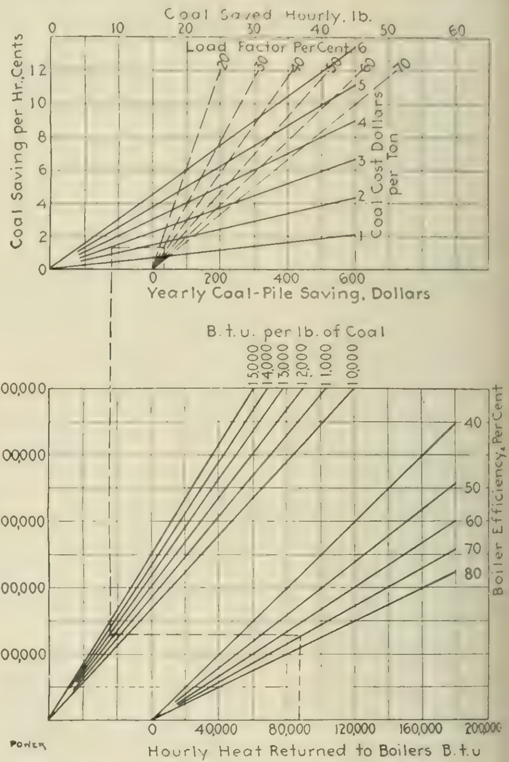


FIG. 3. SAVING IN COAL EFFECTED BY HEATERS

There are bound to be errors of some magnitude in the results obtained from the use of such charts unless they are drawn to large scale. The results obtained, however, should be as accurate as the assumptions upon which computations must be based.

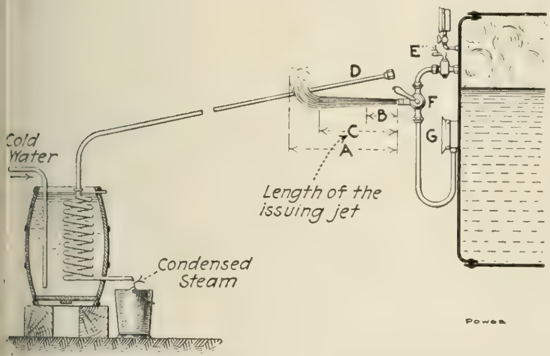
⁂

In order, therefore, that the technical man who in material things knows what to do and how to do it, may be able to get the thing done and to direct the doing of it, he must be an engineer of men and of capital as well as of the materials and forces of nature. In other words, he must cultivate human interests, human learning, human associations, and avail himself of every opportunity to further these personal and business relations.—"Johnson."

Measuring Steam Leakage

It is a practice among engineers to close the steam and the exhaust valves, then to open the indicator cock, after the cylinder has had time to fill with steam, and judge by the duration and intensity of the discharge how badly the inlet valves are leaking. F. Gyseling, technical director of the Bollinckx establishment at Brussels, has carried out a series of interesting experiments to determine the quantity of steam delivered by a jet of given size based upon the length to which the jet carries.

Referring to the diagram, steam was admitted through the regulating cock *E* to the three-way indicator cock *F*, and the length of the issuing jet measured as shown, the distance *B* being that at which the hand could be held, and the distance *C* the length of the jet in the axis of the discharge, the distance *A* being the total length. The steam gage *G* indicated the pressure at which the jet ssued. After the jet had been measured, and without disturbing the adjustment of the cock *E*, the pipe *D* was connected to the indicator cock and the steam discharged for an observed time, condensed and weighed. The results obtained were as follows:



MEASURING STEAM FLOW BY THE LENGTH OF THE JET

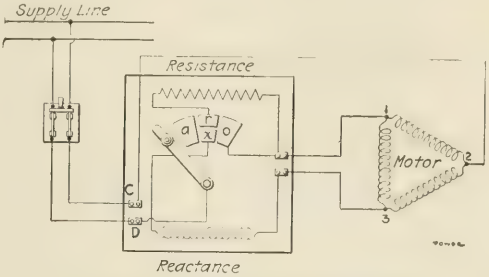
	Meters	Inches	Meters	Inches	Meters	Inches	Meters	Inches	Meters	Inches
Total length (A) of jet	0 90	35.4	1.10	43 3	1 60	63 0	2 10	82.7	2.50	98.4
Length (C) of jet in axis of nozzle	0.45	17.7	0 60	23.6	1 00	39.4	1.50	59	2 00	78.7
Distance (B) at which hand can be held	0.30	11.8	0 34	13.4	0 40	15.7	0 45	17.7	0.50	19.7
	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.
Pressure on gage C condensing	0	0	0	0	0 04	0.59	0 19	2.79	0.24	3.53
Pressure on gage D discharging tests	0	0.	0.	0.	0.02	0 29	0 16	2 35	0.22	3.23
Pressure in boiler	7 50	110 2	7 50	110.2	7 55	111.	7 60	111.7	7 60	111.7
	Kg.	Lb.	Kg	Lb.	Kg.	Lb.	Kg.	Lb.	Kg.	Lb.
Weight of steam discharged per hr	2 98	6.55	4 18	9.2	11.63	25.59	29.235	64 32	33.28	73.21

* * *

Applying Instruments to Split-Phase Starters

In applying the voltmeter and ammeter to test a three-phase motor operated from a single-phase line by means of a reactor-resistor phase-splitting starter, the fact that the motor is started as a three-phase machine but operates as a single-phase motor, is to be borne in mind; otherwise the readings obtained may be wrongly interpreted.

In the accompanying diagrammatic sketch of such a tarter, it will be noted that only when the starter handle rests on segments *r* and *x* do all the motor leads carry current. As soon as the starter handle is moved to the unning position *o*, the motor lead that is connected to he reactance becomes dead as far as carrying motor current is concerned. Therefore, an ammeter connected into it would indicate current only on the starting position of the starter. Furthermore, only when a voltmeter is applied to the motor leads 1 and 2 will the actual voltage of operation be indicated, because when the instrument is applied across either of the other two legs, it has in series with it one motor coil that acts as a multiplier to decrease its reading.



SKETCH OF SPLIT-PHASE STARTER

An operator, whose real trouble was heavy overload, measured the voltage across the three legs of his motor; when he got 95 volts on each of two legs and 110 volts on the third one, he attributed his trouble to unbalanced voltages and called in an inspector to locate the cause.

* * *

Overmotoring

By overmotoring is meant the use of a motor that is too large for the duty that it has to perform. To have a motor sufficiently large for the work is good judgment; to have it too large may represent investment that occupies floor space and pays no interest.

For a motor that operates under steady load, heating is the criterion; for one that is subjected to frequent starts, sparking at the brushes is usually a safe guide, assuming that the starting devices have the proper characteristics. From a meter point of view, it is advantageous to have a motor operate at high efficiency; for motors operating on steady loads, this means loads of from 75 to 125 per cent. of full load. With motors on intermittent service, such as railways, the higher efficiencies may obtain at lesser loads.

Ordinary induction motors and compound-wound and shunt-wound direct-current motors, have no speed complications incident to light loads. Induction motors are selected to operate at or near full load not only because the resulting efficiencies are better, as is true of all motors, but at light loads they have poor power factors tending to lower the power factor of the system on which they operate. Series motors may be even dangerous on light loads, because under such a condition they tend to race and the extent to which they race depends upon how light the load is. Racing, especially where the mechanical load is connected through gears, sets up vibration tending to deteriorate all mechanisms within its influence.

Vibration also reacts upon the motor bearings, and centrifugal forces, incident to excessive speed, subject the armature to stresses beyond what they may have been designed to withstand.

An inspector was called in to locate the trouble with a series motor-operated electric crane, the electrical equipment of which had given considerable trouble. All three crane motions were derived from the same motor, one motion or the other being engaged by means of a lever mechanism; this meant that when the crane was being used, the motor ran continuously during much of the time. The load was imposed through a train of gears, so that the speed was abnormally high.

Application of an ammeter showed that with the heaviest load the crane would be called upon to handle the motor would not be half loaded. The situation was temporarily relieved by connecting a resistance into the supply circuit, and it was permanently relieved by the substitution of a motor of about half the rating of the first machine.

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Losses in Boiler Operation

By Victor J. Azbe

SYNOPSIS—The eight chief factors producing heat loss in boiler operation are: Heat carried off by flue gases; incomplete combustion; unburned carbon escaping up the chimney or depositing in the boiler, etc.; unburned carbon dropping through the grates; moisture in the fuel; formation of water by the combustion of hydrogen; water vapor in the air; and radiation. The author discusses these losses, their relative importance and means for preventing or minimizing them.

*

Heat Carried Off by Flue Gases

The temperature of the escaping gases is greatly influenced by the area and condition of the heating surface. If the heating surface is maintained clean, inside and out, the temperature can only be reduced by increasing the area. Thus, economizers are often advantageous. Economizers, however, usually require mechanical draft and the interest on the cost of installation, maintenance expense, etc., must be carefully considered in connection with the saving in fuel cost to be obtained.

The economizer increases the heating surface; the flue brush, tube cleaner and scale-preventing methods increase its efficiency. Soot is one of the poorest conductors of heat. There are only two substances which exceed soot in this respect, wool and feathers. Asbestos is a poor conductor of heat and, hence, is used for covering steam pipes. If the boiler-heating surface were covered with asbestos 1½ in. thick, no power-plant manager would spare any effort or expense to remove this covering as soon as possible. Soot is probably five times as poor a conductor of heat as asbestos, thus, ¼ in. of soot is equal in value to 1¼ in. of asbestos.

Scale also is a poor conductor of heat. Its conductivity cannot be stated because this varies with its composition. Even though the conductivity of soot is greater than that of scale, scale is more dangerous to the boiler, because soot simply prevents the gases from coming in contact with the shell and giving up their heat to the water in the boiler, while scale prevents the water from coming in contact with the boiler plates and absorbing the heat. Consequently, if the heat is supplied to the metal faster than it is absorbed, the plates and tubes are in danger of being overheated.

If the amount of air supplied per pound of coal is known, it is comparatively simple to calculate the loss due to the heat carried off by the flue gases. Multiply the weight of the gases formed (weight of air supplied plus weight of combustible per pound of coal) by the specific heat of the gases and the difference in temperature between the gases and the outside air. Thus, if the gas analysis showed that 17 lb. of air was being supplied per pound of coal; if the coal contained 80 per cent. combustible matter and the temperature of the flue gases was 500 deg. F. and that of the outside air 70 deg., the heat carried off per pound of coal would be

$$(17 + 0.80) \times (500 - 70) \times 0.24 = 1837 \textit{ B.t.u.}$$

(0.24 is the commonly accepted figure for the specific heat of the flue gases).

By careful regulation of the air supply the heat lost with the flue gases can be kept within reasonable limits. Every pound of air put through the furnace in excess of what is required by good operation only serves as a sponge to soak up heat and carry it off to no useful purpose. It is safe to say that, in the average boiler room, where conditions are not carefully controlled, 40 per cent. or more of the latent heat of the fuel is lost, of which at least one-quarter could be saved. In some power plants the writer found the conditions so bad that 50 per cent. of the coal fired was as good as thrown away. There were very few plants in which the preventable loss amounted to less than 10 per cent.

To prevent waste through excess air close attention must be paid to the draft and fuel bed. Most plants suffer from too thin a fire or too strong a draft. A CO_2 recorder or, at least, a hand gas-analyzing instrument with a gas collector, and a draft gage, would enable the engineer to prevent wastes by adjusting the draft to the thickness of the fuel bed, or the thickness of the fuel bed to the draft. Without them close adjustment is impossible. When the draft is increased without a change being made in the thickness of the fuel bed the rate of boiler output is somewhat increased, but the efficiency of combustion is lowered. The amount of draft that should be used is that which will supply the right amount of air for the fuel on the grates, and when the correct amount is used the analysis of the flue gases will show a high percentage of CO_2. In plants having more than one boiler in service the draft should be equalized in all the furnaces. In many plants twice as strong a draft is used in one boiler as in another. Often the boiler nearest the chimney and with the stronger draft will use too much air and thus waste fuel, while a further boiler with a weak draft will not get enough air and, hence, will produce smoke and waste fuel through incomplete combustion.

Incomplete Combustion and Smoke

The second and third causes of heat loss are incomplete combustion and the escape of unburned carbon up the chimney. Incomplete combustion is caused by insufficient air, low temperature, or the imperfect mixture of the combustible gases with the air. Carbon when completely burned gives up 14,600 B.t.u. per pound. When incompletely burned the heat generated is less than one-third of this, or 4450 B.t.u. In the first case the carbon and oxygen combined in the proportion of 1 lb. of carbon to $2\frac{2}{3}$ lb. of oxygen. In the second, 1 lb. of carbon combined with half or only $1\frac{1}{3}$ lb. of oxygen.

The volatile matter of the coal burns in the combustion chamber; the fixed or free carbon burns on the grates. From this it is seen that the larger the percentage of volatile matter in coal, the larger and roomier the combustion chamber should be. Coal that can be burned smokelessly in one furnace may smoke badly in another. Anthracite is practically smokeless because it contains very little volatile matter. Bituminous coals cannot be burned smokelessly in furnaces constructed for anthracite. With bituminous coals the boiler shell or tubes must be placed some distance from the grate to prevent the gases from coming too quickly into contact with the comparatively cool metal. The temperature of the boiler shell is but slightly above the temperature of the water in the boiler, which at 100 lb. steam pressure is 337.5 deg. F. This is far below the ignition point of the combustible gases and vapors some of which decompose and precipitate carbon which deposits on the heating surface of the boiler as soot or escapes through the chimney as smoke.

To prevent incomplete combustion and insure smokelessness, first, the required amount of air must be admitted; second, this air must be brought into contact and mixed with the combustible gases, and, third, a high furnace temperature must be maintained. Any one or two of these conditions will not prevent the loss due to the formation of CO or smoke. With hand-fired furnaces, to supply the required amount of air for the complete combustion of the volatile combustible matter when fresh coal is put in, it is often necessary to admit some air above the bed. Most of the so called smoke consumers, which should be called smoke preventers, are constructed on this principle of admitting air above the fire. The main trouble is that it is practically impossible to admit the correct amount and the cold incoming air chills the furnace and arrests combustion.

This air supply above the fuel bed is required only while the distillation of volatile matter is heavy, as for a few minutes after a new charge of coal, and the supply should be shut off as soon as smoke ceases to escape. Smoke indicators are of value because they show the fireman whether smoke is being emitted or not, and they assist him to determine what amount of air he ought to use to prevent smoke. The actual loss due to smoke alone, which is very small, is generally overestimated. With the very densest smoke the loss never amounts to more than 2 per cent. of the coal fired. If this were the only loss smoke could be neglected in most cases, as far as economy goes. But smoke is always accompanied by valuable combustible gases and vapors.

There are objections to smoke from the hygienic standpoint and others, but as these do not come under the head of power-plant operation, they are neglected here.

While smoke always indicates imperfect combustion, the absence of it is no indication of ideal conditions, because the invisible combustible gases may be escaping undetected. In down-draft furnaces the volatile matter passes through the highly-heated fuel bed and if the air supply is sufficient, this volatile matter will be completely consumed. If, however, the air supply is insufficient, waste results, although smokeless conditions will still be maintained. This is because, when CO_2 comes in contact with incandescent carbon, it gives up half of its oxygen to form double the amount of CO.

Properly designed dutch ovens are valuable as smoke preventers. In them the burning of the fuel takes place in a chamber separate from the space where with the ordinary arrangement of furnace the fuel is burned. With such design there is less danger of combustion being checked due to the flame coming in contact with a cool surface as the furnace is of brick throughout and the bricks act as heat accumulators. When a fresh charge is thrown in, vaporization of the moisture and gasification of the volatile matter take place, both of which processes require heat. As the brick walls are at a high temperature, they give off heat and thus prevent the furnace temperature from dropping below the ignition point of the combustible gases.

Unburned Carbon Dropping Through Grate

The fourth loss, due to the unburned carbon dropping through the grate, depends greatly upon the percentage of ash in the coal. A high percentage of ash in the coal means a high percentage of unburned carbon falling through the grate because the fire needs more frequent cleaning and hence more unburned coal is lost. A high ash content is also objectionable in other ways. The larger the percentage of ash, the smaller the percentage of combustible matter. High ash makes good air distribution difficult and, hence, frequently requires an unusually large excess air supply. High ash also increases the labor cost. The air spaces in the grate must be large enough to allow the required amount of air to flow through, but at the same time they must not be too large, else too much unburned fuel will fall through.

Moisture in Fuel

The fifth loss is that due to the moisture in the fuel. To heat 1 lb. of water 1 deg., 1 B.t.u. is required. To evaporate this pound of water from 212 deg. into steam at the same temperature, 970.4 B.t.u. are needed. To superheat this pound of steam 1 deg. requires about 0.45 B.t.u. To illustrate how the loss due to the moisture is calculated, assume a coal containing 5 per cent. moisture; the temperature of the coal when fired is 70 deg. and the temperature of the flue gas 500 deg. To raise the temperature of the water contained in 1 lb. of coal from 70 to 212 deg., would require

$$0.05 \times (212 - 70) = 7.1 \textit{ B.t.u.}$$

To evaporate this water into steam would require

$$0.05 \times 970.4 = 48.52 \textit{ B.t.u.}$$

And to superheat the steam from 212 to 500 deg. would require

$$0.05 \times (500 - 212) \times 0.45 = 6.48 \textit{ B.t.u.}$$

Adding these quantities together gives 62.10 B.t.u., which is lost with each pound of coal burned. If the coal had a heat value of 12,000 B.t.u. as fired the percentage of loss would be

$$62.1 \div 12{,}000 \times 100 = 0.52 \textit{ per cent.}$$

This is not much, but, considering that this moisture was paid for the same as the combustible matter of the coal, and, of each hundred dollars spent, five dollars went to pay for the moisture, it is not only useless, but causes a loss in the furnace as well.

In some plants a practice is made of wetting the coal. No doubt with some coal, especially slack, this is beneficial. The engineer should remember, however, before allowing the fireman to wet the coal more than merely necessary to prevent dust, that the larger the amount of water evaporated in the furnace, the smaller will be the amount evaporated in the boiler.

FORMATION OF WATER

The sixth loss is due to the moisture formed by the combustion of the hydrogen in the coal. This hydrogen content runs from 3 to 6 per cent. In burning, hydrogen combines with oxygen and forms water, 1 lb. requiring 8 lb. of oxygen and forming 9 lb. of water. About 18 per cent. of the heat credited to the hydrogen is lost when it is burned in the furnace. The heat value of a pound of hydrogen obtained when it is burned in a calorimeter, where the products of combustion are cooled to about ordinary atmospheric temperature and then calculated to a basis of 32 deg., is 62,000 B.t.u. In a boiler furnace the gases ordinarily escape at a temperature of 500 deg. or more, which is far above 212 deg., the point where the vapor would begin to condense and give up its latent heat. Thus, this latent heat is lost as well as all the sensible heat of both water and vapor above the temperature on which the heat value of hydrogen is based.

WATER VAPOR IN THE AIR

The seventh loss is that due to the water vapor in the air. The loss per pound of coal fired, due to moisture in the air, is calculated by multiplying the weight of the moisture contained in the air supplied per pound of coal, the specific heat of steam (water vapor) and the difference in temperature between the flue gases and outside air. The weight of moisture in the air is found by multiplying the relative humidity, expressed as a fraction, by the weight of moisture in 1 lb. of air saturated with moisture. As the direct loss due to moisture in the air is small, and cannot be controlled, and as the data needed to estimate this loss are not often available, this loss is seldom entered as a separate item in the heat balance, but is simply included in the "unaccounted-for" item.

RADIATION

The eighth loss is that due to the radiation of heat from the furnace walls. To lower this loss boiler settings are generally constructed with double walls with an air space between and until recently the opinion prevailed that the air, which is a very poor conductor of heat, served greatly to prevent the heat from being conducted through the walls. However, recent tests made by the government proved that this is not so and that a solid wall is a better insulator than two walls with an air space between. The conduction of heat by the air space is really smaller but the radiation across the empty space is great. For this reason it is desirable to fill this air space with some loose material as sand, broken brick, etc. It is good practice to cover the outside surface of the boiler walls with some nonconducting substance as asbestos, magnesia, etc. This not only diminishes the escape of heat from the boiler settings, but also the air infiltration through the brick work.

In conclusion, it is well to give due attention to the condition of all boiler walls, for in many plants 5 per cent. or more of the coal is wasted simply because the walls are cracked and allow air to leak into the furnace.

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Furnace Losses and Air Requirements

BY HAYLETT O'NEILL

It is the purpose of the accompanying charts to show graphically the furnace losses resulting from incomplete combustion of coal, as indicated by the percentage of carbon monoxide (CO) in the flue gas and also to show the amount of air required, as in a forced-draft equipment, to produce a certain combustion. A very small percentage of CO represents a large loss, especially if the percentage of CO_2 is small. For example, assuming products of combustion of coal running 14,300 B.t.u. and 80 per cent. carbon, to contain 6 per cent. CO_2 and 0.2 per cent. CO, the loss on account of CO is 325 B.t.u. per lb. of carbon, or 260 B.t.u. per lb. of coal. With gas containing 16 per cent. CO_2, the loss is 130 B.t.u. per lb. of carbon, or 104 B.t.u. per lb. of coal. The charts are self-explanatory and convenient for ready reference.

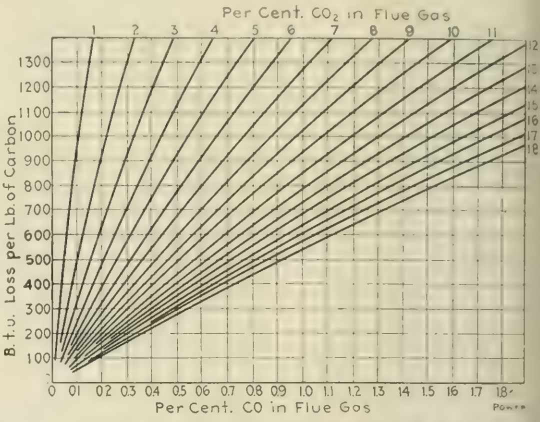

FIG. 1. HEAT LOSS PER POUND OF CARBON DUE TO INCOMPLETE COMBUSTION

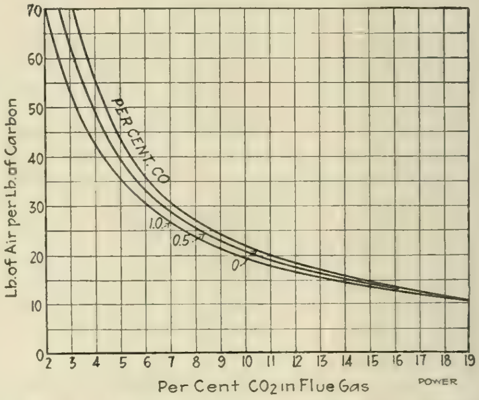

FIG. 2. AIR-SUPPLY REQUIREMENTS TO PRODUCE A CERTAIN COMBUSTION

Experience with Closed Water Heaters

By A. C. Waldron

SYNOPSIS—Some troubles with leaky feed-water heaters of the closed type are described. The pressure put on closed heaters by the expansion of the water is usually the cause of leaks.

One of the most common troubles experienced in taking charge of steam plants is to find the feed-water heater leaking water from the outer casing and bolted flanged joints. Upon inquiry one is invariably informed that the heater had always leaked, for it is not always an easy matter to pack the flanges, and again it is generally a Sunday or a night job. In one plant the writer had a hot-water heater, Fig. 1, which consisted of a 2½-in. coil, which carried cold water and through this coil was passed a ¾-in. brass, live-steam pipe connected to a trap. At the end of the coil was a thermostat which, by turning the wheel *A* either way, would set it to operate for either hotter or colder water. The diaphragm valve was operated by city water pressure. The pet-cock *B* had to be kept slightly open all the time so that when the thermostat shuts the city pressure off the ¼-in. pipe *B*, the open pet-cock *D* will relieve all pressure and the spring *C* will push up the diaphragm and open the valve *D*, admitting more live steam to the coils.

The bolted flanges $E_1E_2E_3E_4E_5$ were invariably leaking, especially after the valves *F* and *G* were closed, as there was no relief valve on this coil, and the water was allowed to heat up, producing a pressure of about 500 lb., due to the expansion of the water. It was not until after a relief valve was put on that the flanges could be kept tight.

Fig. 2 shows a heater found leaking at the flanges A_1A_2. The cap at the top leaked so badly that water would accumulate in the steam space, and cause serious water-hammer. This heater did not have a relief valve and so had to withstand high water pressures when the feed-water valves were closed. Copper and lead gaskets were renewed frequently on the flanges of several such heaters. The writer has operated the heater, Fig. 3, which, because of its construction, allows for expansion. The pressure in this type of heater is confined to the coils. A relief valve should be attached to the heater coil between the heater and the outlet valve. The relief valve on the heater referred to was set to operate at 200 lb. pressure, and every night when the valves on the inlet and outlet of the heater coil were closed, the relief valve would run a stream of water while the engine was running.

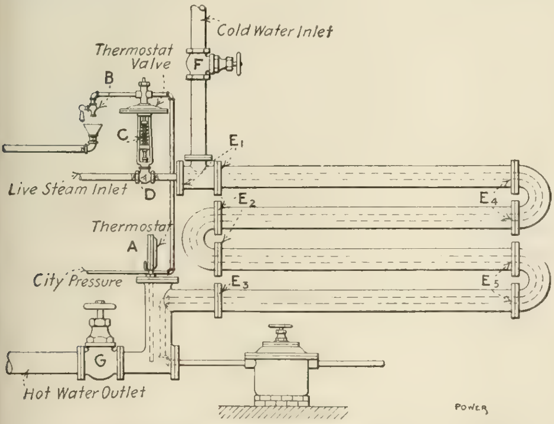

Fig. 1. Flanges Leaked on This Coil Heater

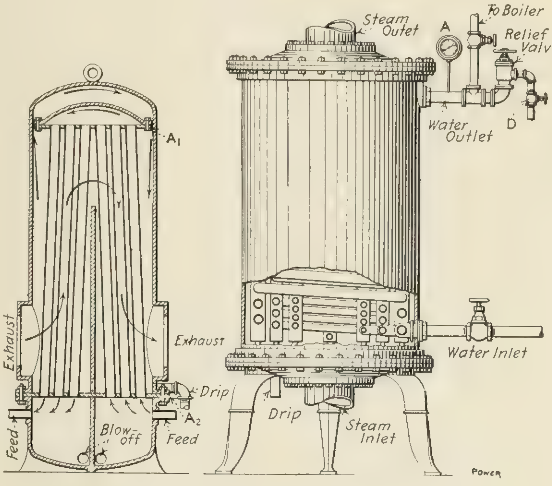

Fig. 2. Fig. 3.

Fig. 2. The Large Flanges A_1 and A_2 Leaked Due to High Pressure. Fig. 3. Expansion of Water Subjected This Heater to 500 Lb. Pressure.

Determined to ascertain how much pressure would accumulate if the relief valve was made inoperative, the writer put a steam gage which registered up to 300 lb. at *A* and a valve at *D* and closed the valve *D*. Steam was sent to the heater and the gage pointer started to move, and went around by the 300 mark and hard up against the stop pin. The approximate pressure in the coils and piping due to the expansion of the water was 500 lb. but even at this pressure the tubes did not show any signs of leaking.

It was next decided to determine the cubical contents of the coils by filling them with water at 60 deg. F. The water was drained out and found to weigh 78 lb., or 1¼ cu.ft. Next, the coils were filled with water at 62 deg. F. until water came out of the opening into which the nipple holding the gage had been screwed. Exhaust steam was applied and the water caused to expand, the overflow water being caught in a pail. While heating up to 212 deg., 4 lb., or roughly $^{1}/_{15}$ cu.ft. of water was forced out of the opening and into the pail. This illustrates what a crowding effect there is in closed heaters having no relief valves.

It is too common for firemen to close all the feed valves, thus subjecting a closed heater and the feed lines to pressures that frequently produce serious leaks.

Drying Out Generators and Motors

By H. M. McLellan

When to Dry Out—No machine should be put into service or subjected to a breakdown insulation test when the insulation is damp. This applies to starting up after a long shutdown, as well as to the original start. In some cases the presence of moisture may be detected by inspection, but in others the insulation may be damp yet appear quite dry to the touch. To determine definitely the condition of the insulation, the insulation resistance should be measured. This may be done by means of a megger,* or by the use of direct current and a high-resistance voltmeter. When it is impossible to measure the insulation resistance, it is advisable to dry out the machine as a precautionary measure, for if the drying is properly done, no harm can result.

Whenever insulation resistances are less than the values given below, it may be assumed that the insulation is damp, and the drying out must be continued till these values are obtained.

Machine Voltage	Minimum Insulation Resistance Cold
700 and below	1 megohm (1,000,000 ohms)
Above 700	1500 ohms × voltage of machine

When the machine is heated, the insulation resistance will drop considerably. Therefore, it is necessary to allow the machine to cool after drying before a comparative reading can be obtained.

Time Required—The length of time required for drying will depend upon the thickness of the coils and insulation, upon the condition of the insulation with regard to dampness, and upon the temperature at which the machine is maintained while being dried out. Twenty-four hours is the shortest time that the drying out should be continued before letting the machine cool and taking a resistance reading. The rate of heating should be such that the maximum temperature will be reached in from three to four hours. Resistance readings should be taken from time to time as the machine cools off, for these readings may indicate whether the drying has been carried far enough without waiting for the machine to cool.

Caution—Several thermometers should be placed in contact with the coils, which should be kept at a temperature of about 60 deg. C. (140 deg. F.)

While being dried out, the machine must never be left without attendance, and temperature readings must be taken at regular intervals. Failure to follow these instructions may mean the destruction of the winding through overheating.

Methods Employed

Alternating-Current Generators—Short-circuit the armature windings, putting an ammeter in at least one phase. Bring the machine up to speed, and strengthen the field until about 1¼ times full-load current flows through the armature. When the desired temperature is reached, the current should be held steady at this value. If the machine is run at less than full speed, the ventilation will not be so good and less current will be required for heating.

Synchronous Motors—A synchronous motor may be treated exactly as a generator. In this case it must, of course, be driven by some external means.

Slip-Ring Motors—Where direct current is available, the motor may be treated as a generator, by short-circuiting the stator winding and impressing direct current on two of the rotor slip-rings. It is, of course, necessary that the motor be driven by some external means, and the stator winding must never be opened while there is voltage on the rotor.

Squirrel-Cage Motors—The best way to proceed in this case is to lock the rotor and impress a very low voltage across the stator terminals. Since the rotor is stationary, the cooling will be poor, and considerably less than full-load current will probably be required. Usually about one-tenth normal voltage will be sufficient to produce the desired temperature, and care must be exercised to see that no part of the machine is overheated.

It is, of course, possible to dry out any alternating-current machine by passing direct current through the windings, but in general this is less satisfactory than the methods described, and provisions must be made to insure equal currents in all the phases.

Direct-Current Generators—Short-circuit the machine through an ammeter (with a shunt) and run it at slow speed with a weak field. Shut down at regular intervals and measure the temperature, and adjust the current to give the desired temperature rise. When a constant temperature has been reached, it is not necessary to shut down except at long intervals, the heating being adjusted by the current through the armature.

Direct-Current Motors—If the machine can be driven, it may be treated as a generator. If not, the armature should be securely locked and current passed through it by way of the commutator and brushes. Since the armature is stationary, less than full-load current will usually be required. A heavy tension should be placed on the brushes, to insure good contact with the commutator, and care must be taken to see that no burning occurs.

General—Another excellent method applicable to all classes of machines is that of drying with hot air from a stove. It is particularly applicable where a large number of small machines are to be dried out. The machine must be inclosed in some form of heat-insulating box, which box should, if possible, be made of sheet iron and lined with asbestos. The temperature inside the box is raised by means of an electrical resistance or by a stove. The temperature in any part of this inclosure should not exceed 90 deg. C. (194 deg. F.), and where stoves are used the smoke or gases given off should not be permitted to come in direct contact with the windings. A supply of fresh air should be admitted at the bottom of the box, and arrangements made so that after being heated it comes in contact with the windings and then escapes at the top. Where electrical resistances are being used, the wiring and resistances must be so arranged that an arc cannot possibly occur inside the box.

Measuring Insulation Resistance by Means of a Direct-Current Voltmeter

First read the voltage across the line. Then connect the voltmeter in series with the insulation to be measured

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*An instrument consisting essentially of a high-tension magneto and galvanometer and calibrated to read in megohms.

(i.e., between a commutator bar and the shaft, slip rings and the shaft or between the terminals of the winding and the frame, etc.) and read the volts again.

If R is the resistance of the voltmeter, V the reading across the busbars, V' the reading of the voltmeter when in series with the insulation, then the resistance of the insulation is

$$R' = \frac{R\,(V - V')}{V'}$$

If $R = 100{,}000$ ohms;
$V = 500$ ohms;
$V' = 100$ ohms;

$$R' = \frac{100{,}000\,(500 - 100)}{100} = 400{,}000 \text{ ohms}$$

The resistance of the voltmeter is usually marked on the back of the instrument or on the carrying case; if not, it may be obtained from the makers. A voltmeter with as high a resistance as possible should always be chosen.

Points on Babbitting

By L. D. Allen

SYNOPSIS—Where to look for and how to avoid bearing troubles. Hints on how to secure good results when babbitting a bearing.

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In a previous article,* attention was directed to the heavy frictional expense incident to the operation of machinery throughout a mill or factory; to the requirements of a good babbitt; to the fact that its wearing qualities are dependent quite as much on its structure and the way it is made and handled as on its composition; and to the properties of many of the ingredients of bearing alloys.

Cause of Bearing Troubles

In searching for the cause of bearing troubles, first look into bearing conditions; then determine whether the babbitt is a lead-based, a semi-tin-based or a tin-based metal, and, finally, break several bars of the metal to ascertain the extent of its hardness and homogeneity. If the metal is suitable for the conditions to be met, then the bearing trouble must be sought in some one or several of the following causes: Excessive bearing pressure, insufficient bearing area, journal too small, shaft out of alignment, bearing warped, metal burned or not properly stirred when applied, bearing too tight or too loose on the sides, presence of abrasive or cutting particles, defective lubricating appliances, inferior lubricants, wick glazed, clogged or leaving insufficient capillary power, oiling rings or chains broken or jammed, cups clogged, and, last but not least, negligence.

Carelessness

One of the frequent causes of bearing troubles, aside from poor or defective lubrication, is an imperfect understanding as to the proper handling of the babbitt in melting and applying it to the bearing, or else to that carelessness which often results from familiarity or a long run of successful babbittings. As an illustration, take the brakeman on a railroad train. When he first starts out he is cautious, but with increasing familiarity and good luck he becomes careless, and the unexpected occurs. There are companies which have used a certain grade of babbitt for years with satisfactory results, and then suddenly they have trouble from hot boxes, flaking metal, etc. The metal is blamed, whereas the trouble was not due to a change in its grade. Either a different man did the babbitting and did not handle the metal right in one or two important details, or the same man had had good results so long that he had gradually dropped one precaution after another until he was getting uneven mixtures, burnt metal or oxides in the bearings; perhaps the lubricant or bearing conditions had been subjected to a similar change in attention.

Pouring the Metal

Proper babbitting conditions require clean pots and ladles. A hot pot or ladle can be quickly cleaned by brushing it with powdered resin and then removing the precipitant. It is always best to melt the babbitt in a pot or kettle and not in a ladle, the latter being too small to insure an even temperature and proper stirring. It is important that the ladle should be large enough to contain more metal than is necessary to fill the bearing. If the bearing is long, be sure that the gate into which the metal is poured is amply large so that enough metal enters at a time to reach the farthest point of the bearing without chilling; otherwise the result will be an imperfect bearing.

One concern changed from a lead-based to an expensive tin-based metal because many of the bearings had cracked and rattled loose. A tougher metal was thought necessary. Accidentally, it was found afterward that the trouble had been caused by using too small a ladle in pouring. These bearings required more than one ladleful, and, while they were dipping for sufficient metal to complete the pouring, that already in the bearing would set just enough so that when the balance of the babbitt was poured a seam would form between the two parts. When this bearing was put into service the jar on the journal caused it to crack at the seam. The firm changed back to the lead-based metal, used a ladle large enough for one pouring to a bearing, and the trouble ceased.

Temperatures

Overheating the babbitt makes it brittle. Further, the hot metal tends to shrink as it comes in contact with the colder surface, resulting sometimes in a loose lining which soon cracks under heavy stress or jarring. The temperature at which to pour a metal composed of tin, lead and antimony, and not over 0.5 per cent. copper if it is a lead-based metal, not over 2 per cent. if it is a semi-tin-based metal or not over 5 per cent. if it is a tin-based metal, may be determined by inserting a white pine stick. If it is heavily browned or slightly charred, the proper temperature has been reached. Another indication is a yellowish tinge forming on the surface of the metal. Do not wait until a red oxide forms. A metal containing zinc or considerable copper must be heated until it can be poured freely.

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*"Bearing Metal Manufacture and Use," Mar. 3, 1914, issue.

The bearing into which hot metal is poured, and also the mandrel, shaft or journal, should be heated to about 200 to 300 deg. F.; otherwise the babbitt is likely to resist its contact with the cold surface, thus causing shrinkage and an imperfect bearing. A shaft or mandrel should be well chalked to insure freedom from grease and dampness. If the shaft has not been heated, the chalking will prevent the formation of blow holes and rough surfaces on the face of the bearing. Shells or bushings should be treated in the same way. Small bearings are best poured vertically and large ones horizontally, with a large gate on top for the metal. Clay is the best material to use where it is desired to keep the metal from running out.

Another frequent source of trouble is that the kettle and the bearing are too far apart; then the metals chills or separates before it is poured. When the bearing cannot be brought close to the pot a portable furnace should be used. Hold the ladle close to the bearings to prevent air bubbles and cooling, and see that there is sufficient vent for the escaping gases.

Babbitt poured into a mold or bearing at a temperature far above its proper melting point is generally coarse grained and makes a poor lining. Rapid cooling produces a fine, even grain.

Sometimes, when getting in a new lot of metal, a purchaser will compare it with some of the old metal on hand by hitting the bars together. Usually the old bar will dent the new, indicating that the new metal is softer and raising a question as to whether the grade and quality are the same as formerly. Undoubtedly, they are, if the metal manufacturer has a reputation for reliability, but the difference is that metal carried in stock for several weeks or months is harder than the same grade when first made.

IRREGULARITIES

Peening the lining of a bearing is of no special value except in the case of shrinkage, when tightening the metal in place or evening up the surface in the event of some irregularity from pouring. If it is necessary to peen the metal to tighten it, the best way is to take a round-faced hammer and tap the bearing lightly up and down a line parallel to the axis, gradually extending the blows to the right and the left until the metal is tightened in place.

Boxes should be kept snug but should not be keyed down too tightly at the start, at least not until the rough places on the bearing have been worn smooth. A journal should rest evenly on a bearing. Weight unevenly distributed by a shaft out of alignment is disastrous to the babbitt, and particularly to a lead-based metal. This defect once caused a millwright to change from a cool-running, durable, lead-based anti-friction metal to an expensive tin-based metal, which stood the stress only because of its toughness, whereas it really developed higher friction and greater cost in other directions through lack of its anti-frictional properties.

There is no excuse for a poor bearing, so far as its being a smooth, solid, good fitting casting is concerned, if all dampness and grease are removed, the mandrel or shaft and the back of the bearing are properly warmed; the shaft is wrapped with a thickness equal to the oil space required between the shaft and the bearing surface; if the metal is fluid, its temperature right and it is thoroughly stirred and all oxides removed; if the gate into which the metal is poured is large enough to admit a volume that will reach all parts of the bearing quickly before chilling at any one point.

If a bearing warms up when first started, it is usually because of the little uneven projections that are being worn down. By letting the bearing run a few moments, stopping it to cool off and then starting it again, a cool-running bearing usually results, other conditions being all right.

If a metal flakes off or contains hard and soft spots and is pronounced too soft, it is usually because the metal has been left too long in a highly fluid state without stirring. This allows the metals to separate, and instead of a homogeneous mixture there is a segregation of the lead, tin and antimony, and trouble naturally follows.

GRADES OF BABBITT

Bearing metals should be selected according to the speeds and pressures, the size of the bearing and the thickness of the babbitt lining. It is not necessary that a different babbitt be used for each slight variation, but a different grade is preferable where the conditions are radically different. Practically three grades will cover all mechanical conditions; one for general light work, one for medium-speed and pressure and one for high-speed, heavy-duty work, with now and then an exception; i.e., an extremely heavy load with low speed, a high speed with a comparatively light load, or a small, thin-shelled bearing built out of all proportion to the load and to the speed. While one or two grades might generally give satisfaction, economy would be better served by selecting a grade best suited to one of these three or to the special conditions. Because a man is getting what he considers good service out of his 16c., 20c., or 25c. metal, it is no assurance that for 30c. per lb. he might not get double the service, or that for 14c. he might not get the same service.

Sometimes the mistake is made, in small thin bearings, of making too large oil holes and deep grooves in various directions from the oil holes. This skeletonizes and weakens the bushing. These grooves occasionally extend through half the thickness of the lining, and under constant vibration or jar, the bushings crack. The remedy is thicker linings or bushings, or else sufficient tin added to the babbitt to make it tough enough to withstand this condition. Some wash the backing against which the metal is to be poured with the ordinary plumber soldering solution so that the babbitt is soldered fast to the box or backing.

If the metal pours sluggishly, the trouble may be looked for either in the temperature being too low, or the metal containing too much copper or zinc. The increased use of smeltered or dross products and antimonial lead containing impurities in considerable quantities frequently causes this trouble.

Assuming that the metal is made right, and of the right materials, then the important features to be observed are that the right grade is selected for the condition to be met; that it is handled properly in babbitting; and that as many as possible of the conditions that tend to destroy the babbitt lining are removed.

Editorials

What Are You Working For?

Ask anyone what the difference is between a profession and a trade, and the answer will almost certainly be one relating to the character of the work. Probably the law, the ministry, or medicine will be mentioned as examples of professions, and carpentry, masonry, tailoring, farming or any other of a number of callings, as trades. We submit that the real distinction between a profession and a trade is the spirit in which it is usually followed. Viewed in this light, your vocation is the one or the other according to whether you engage in it for what you put in it, or what you get out of it. In other words, whether you work for the love of it, or for the money it brings.

It is contrary to human instinct to be idle. Some naturally prefer the good and live to be useful; others, evilly inclined, if useful at all, are so by compulsion—in order to live. Between these extremes are the careless or discouraged, who work only to get the means of a living.

We would not be misunderstood as meaning that, to be a professional man, one must work for nothing. Money, being the medium of exchange, must be the return to procure the necessities of life and the comforts and recreation that the normal man requires. To this extent, the financial reward is needful in any line of work. Nevertheless, the truly professional man who deserves the dignity of that classification makes his chief concern the good he can do. He is more anxious to be useful than rich.

Common acceptance of the term makes all clergymen, doctors and lawyers professional, but, more is the pity, some in their ranks forget that the mission of service is fundamental, the acquisition of wealth incidental. Just as there are these exceptions among those supposed to be of these professional classes, there are many in the humbler walks considered to belong to the trades, who care more to excel in their lines than for anything else. They have a pride in their work and will do as conscientiously whether their wages are high or low.

When the writer was a boy, an old Englishman, an expert wood-polisher, came to the house to polish the rosewood case of an old square piano. He was very enthusiastic over its beautifully matched grain. Constantly, while he worked, he talked about it and admired it and showed his pleasure in polishing it. The interesting part of this incident was the old man's philosophy on the hereafter. His idea of Heaven was a place where everyone could do the work he liked to do and he expected, he said, to go right on polishing wood, because of his fondness for it. Without question, he got a satisfaction out of the work of bringing out the beautiful grain of a piece of woodwork that was akin to that of the artist in putting a picture on a canvas. Probably no one would call wood polishing a profession, but this man had the real professional spirit.

All of this leads up to the fact and perhaps explains why engineering is coming to be—yes, has become a profession. Time was when there were many engineers who went about their work more or less perfunctorily, whose vision held little beyond the pay envelope at the end of the week. Rapidly is this race becoming extinct, even as the lines separating the technically trained from the practically trained engineers are disappearing. We have no patience with the self-considered élite who would have the steam-plant operator known as an engineman or engine runner or something else than engineer. There are many men still left in the plant who do not merit being called engineers yet, and perhaps never will, but those who have reached the stage where they can intelligently manage a plant of any size, are as much entitled to be considered engineers as any.

After all, "What's in a name?" We sense it that, whatever he is called, the man who devotes his life to a work he delights in, who strives to master the knowledge of that work so that he can perform it most effectively, who is earnestly making the most of his ability to be the best of his kind, be it ever so humble, is as much a man as the next. Whether he gets the admiration of the crowd, or is tagged with a title matters not, one thing he has, which no one man can take away from him, an inner satisfaction that he is working for a purpose and getting there. And such a man is any engineer who is making it his main effort to get the highest efficiency or the best performance out of the equipment in his care. He wastes no time in self-pity because he is not getting the salary he earns. Like as not, the lack of salary is more than made up to him in the happiness he gets out of his work, and generally the higher pay comes automatically sooner of later.

Work for the work's sake makes life worth the living.

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Municipal Electric Plants

The opinion is held by many that municipal electric light and power plants are, as a rule, inefficiently operated, give inadequate service and represent a waste of the people's money. While representatives of private power interests have undoubtedly done much to spread this impression, the responsibility also rests with a few plants that have warranted such criticism. However, it would be as unfair to condemn municipal plants, as a class, by the experience of a few unsuccessful ones, as it would be to say that our system of government is a failure because dishonest politicians have discredited it in a few instances.

It should be possible to run a municipal plant as efficiently as a private plant, under like conditions of service; and we believe the majority are so run.

In fairness to the community which it serves, every municipal plant ought to be a self-supporting enterprise. That is, full allowance should be made for interest on the investment, depreciation, retirement of bonds, etc., in addition to the cost of operation, the rates being fixed accordingly. If all the fixed charges were not included, those members of the community who use electricity would profit at the expense of the taxpayers who are not consumers.

There are over fifteen hundred municipal electric-light and power plants in the United States serving private consumers, and about two hundred in Canada, the number having doubled in the last ten years. This growth alone furnishes a strong argument in their favor. In many cases these plants, by furnishing competition, have cut in two the rates formerly paid to private power companies, and still have been able to show a substantial surplus at the end of the year, after deducting all charges. Unfortunately, too little publicity has been given to these cases.

We hope to be able, with the coöperation of municipal plant managements, to compile data on the total cost of production in a large number of these installations. If a sufficient number respond, the results will be classified according to the size of plant, type of equipment and character of service. Published in this form, the information would prove a valuable reference, as it would enable the engineer of any plant to compare his own results with those of other plants operating under similar conditions.

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A Plea for Higher Settings

At a meeting of engineers recently, the disadvantages of small furnace volume or low settings were being discussed. One man inquired as to who started setting boilers close to the grate, and he was informed that the practice started with designers of the craft which plied the Ohio River. Whether this is true matters little, but the fact remains that the practice is all too prevalent.

Nearly everybody realizes that low settings do not favor complete combustion, but instead promote all the evils that tend to lower furnace efficiency, especially with soft coals, the consumption of which is steadily on the increase. This realization makes one wonder why so many engineers are still slaves to a custom that never had any logical application to stationary practice. Imagine how much too low are twenty-four-inch settings for even ordinary soft coal, when at the Delray station of the Detroit Edison Co., the flame of long-flame West Virginia coal strikes the top of the combustion chamber which is twenty-eight feet above the stoker. This happens at a boiler rating of 275 per cent. For complete combustion, the flame should consume itself before striking the comparatively cold heating surface.

In large central stations and railway power houses the value of large furnace volume is fully realized. Each new installation has boilers set higher and higher above the grate.

It is not so long since the water-tube boilers in the South Boston station of the Boston Elevated Rys. Co., were set eight feet above the stokers at the rear. At the time, many thought this was going to extremes and voices of disapproval were heard. New boilers that may be installed in this plant will, perhaps, be set still higher.

At the 201st Street station of the United Electric Light & Power Co., New York City, which is conceded to be one of the best examples of central-station engineering, the boilers are ten feet above the stokers at the rear. Such good results have been obtained with a horizontal-tubular boiler set seventy-six inches above the grate in a Newark, N. J. ice plant, that another boiler with like setting is being installed to meet the steam demands. In the double-furnace water-tube boiler at the Fifty-ninth St. power house of the Interborough Rapid Transit Co., the stoker at the rear of the boiler is about twelve feet below the lowest row of tubes and is more efficient than the one at the front which is located nearer the tubes.

Besides the amelioration of the smoke evil, there are other advantages of high settings which, as the writer pointed out in a recent lecture before Newark Number Three N. A. S. E., are not fully realized. To reduce heat losses due to running boilers at low rating, many engineers use fewer boilers at high rating to carry the load. When burning the fine grades of anthracite under comparatively high draft in ordinarily low settings much of the coal is carried away from the fuel bed. High settings greatly reduce this evil. Where too high ratings are not used, a high volatile and therefore usually cheap coal may be used in high settings without producing objectionable smoke.

⁂

Powdered Coal

A number of inquiries have been received lately for information regarding powdered coal as a fuel. The article on page 470 is a direct response to the evident desire for one of its kind. Interest centers in the practice mainly because of the possibility of utilizing low-grade fuels. Practical difficulties arise in the high furnace temperatures and the finding of a firebrick lining to withstand them.

The author takes up a number of the designs, many of them failures to a greater or less extent and gives reasons for their non-success. Altogther, it is an instructive résumé of the more important work today in this relatively new field, deserving the attention of readers who are following the developments that are being made in fuel engineering.

⁂

In connection with the cartoon this week, if you have not already done so, read the editorial that appeared in the March 21, issue, page 415; entitled "New York State to Economize on Coal." The reference is to the fact that New York State, like New York City, has decided to buy the coal for the plants over which it has control, under specification.

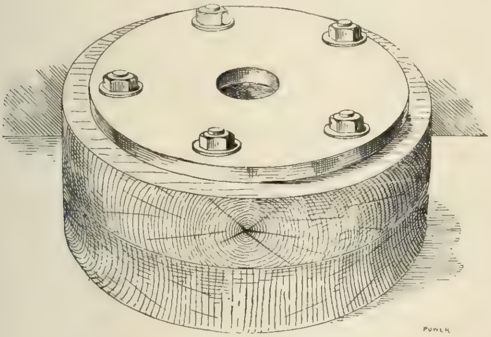
⁂

According to the estimate of Frank Shuman, of Tacony, Philadelphia, the man who has done perhaps the most in that line, the cost of an equipment to absorb energy from the sun would be about $152 per horsepower. An excellent steam plant could be put down for forty dollars, and the standard charges on the one hundred odd in excess of this would pay for coal enough to operate such a plant ten hours a day with coal at three dollars per long ton. It would appear that for the present the sun motor is in the same category as the wave motor. Energy which is now being dissipated can be conserved with either, but at a cost for investment which makes the yearly outlay greater than it would be at the present price of fuel.

Correspondence

An Emergency Pump Piston

An accident happened to the condenser pump during the busy season in a paper mill where I was the operating engineer. The plunger was broken beyond repair, and to avoid shutting down part of the mill, temporary repairs were made, as follows: We measured the exact size of the cylinder, then cut two iron disks $\frac{3}{16}$ in. thick, one inch smaller than the bore. The rod being tapered, one was drilled to fit the large end and the other the small end of the taper. Then two $1\frac{1}{2}$-in. planks were spiked together, and with a keyhole saw sawed out to a plunger $\frac{7}{16}$ in. smaller than the bore of the pump to allow for the wood swelling. After assembling as shown and putting in place, it held a 20-in. vacuum for about one hour, then gradually increased to 23 in., which was maintained for two weeks, until the new parts were received.



Plunger Assembled

J. B. Bedore.

Crivitz, Wis.

Undercutting Commutator Mica

A 15-hp. direct-current motor developed serious sparking at the brushes. It would run satisfactorily for some time, then the commutator would begin to turn black, and the brushes spark and heat to an alarming degree. I tried graphite brushes and boiling the carbon brushes in paraffin, but without success. The armature was removed and placed in a lathe three times to turn down the commutator, but the same trouble appeared after about three months each time.

The last time the armature was removed I decided to undercut the mica. A tool was made a little narrower than the width of the mica, and placed in position. The armature was turned in the lathe until a slot was opposite the tool and then the tool carriage was moved by hand parallel to the commutator, beginning at the outside and working toward the armature coils. After a trip across the commutator the tool was moved back, the armature turned in the lathe until the next slot was opposite the tool and the operation repeated.

In this manner about 156 micas were undercut $^{1}/_{64}$ in. in three-quarters of an hour. When finished, the commutator was polished and put in place. The result was gratifying, the motor running better than it ever did.

I can see no reason why this could not be applied to large motors or dynamos where it would be out of the question to remove the armature. A tool carriage could be fastened to the frame of the machine and operated in the same manner as when in the lathe. The only difficulty might be the inability to move the armature so that a mica would come to rest opposite the travel of the tool.

La Rue H. Stark.

Delavan, Wis.

Magnesia vs. Lime-Mortar Covering

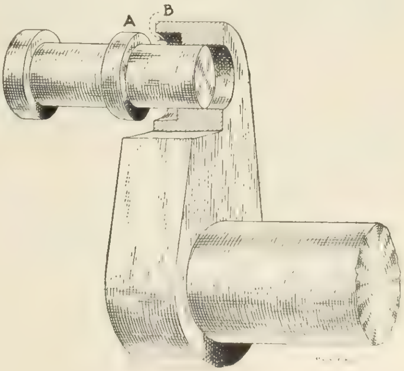
The writer has found magnesia preferable to lime mortar for covering the brickwork on the tops of boilers. Scrape the bricks clean, and apply a first coat of 85 per cent. magnesia, $\frac{1}{8}$ in. thick, mixed as a thin grout. When the first application has become thoroughly dry, apply with a trowel a second coat $\frac{1}{2}$ in. thick, mixed to a consistency of thick mortar. The surface will become firm and will bear walking on.

William Plaisted.

Redondo Beach, Calif.

Crankpin Break

A crankpin brass on a twin-cylinder gas engine suddenly got hot without any perceptible provocation. The engine was shut down and an examination showed that the pin was about half an inch out of the disk. On closer examination it was found that the back end of the pin had not moved, making it plain that the pin was broken in the disk. This pin had given considerable trouble some time before and it was suspected that it was working in the disk, but this could not be detected.



Crankpin and Crank

The old pin was removed and a new one turned down to about the size of the old one. Then the hole in the disk was calipered and found to be in bad shape, but as the nearest portable boring bar was 18 miles away and the engine was needed badly, it was decided to risk putting the new pin in the old hole. Accordingly, the old hole was scraped and filed as smooth as practicable, and the pin finished to what was apparently a good driving fit. The disk was then heated until it would melt solder in the hole. A ram was made from some old shafting suspended on a rope, and a piece of babbitt metal was fastened on the end of a rod to hold over the face of the pin while ramming.

When all was ready, the pin was started in and the ram brought into action. All went well until the pin lacked only about three-fourths of an inch of being home, and there it stuck. No amount of ramming would induce it to go farther; nor could it be backed when the ram was applied to the other end.

The pin was made with a collar *A*, to fit into the counterbore *B*, as shown. We at last decided to cut away the collar, and use the pin as it was until we could get another pin.

A sledge and cold chisel were used to cut the ring down to almost finished size, and then the finished cut was made with the pin-turning device that had been used to true up the old pin. After the pin was smoothed up nicely, the counterbore was filled with babbitt metal flush with the face of the disk. The brass was then put on with about two thicknesses of tin between it and the disk and the space between the brass and the end ring on the pin was filled with babbitt metal.

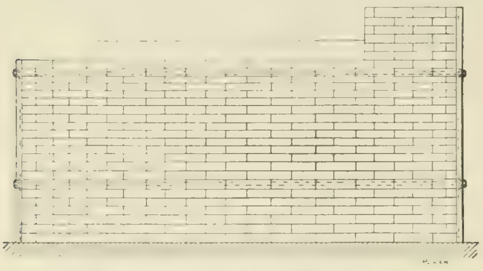
This completed the job. After adjusting the new brass and connecting up, the engine was started and the load put on. The brass ran warm for a day or two, but it is now running cool under full load.

Earl Pagett.

Coffeyville, Kan.

Preventing Cracks in a Boiler Setting

But one side wall of a boiler setting is exposed in my plant, and keeping it in good repair has proved both a difficult and expensive task. When this battery of boilers was originally set, it was allowed to stand for several weeks before fires were built, and the masonry had ample time to dry. Soon after the boiler was put into service, however, cracks appeared in this side wall. About four feet of it was taken down and rebuilt, but cracks soon appeared in the same places. The work was repeated but proved to give no better results than before.



Reinforced Boiler Setting

The rods holding the cast-iron fronts in place were about four feet long, with about six inches at the end, turned at right angles for an anchor. There were no supports at the rear of the wall. On one occasion when the upper part of this wall was taken down for repairs, the short rod was removed and a long one substituted, extending the length of the wall, with a large washer, and a nut at the rear. This was an improvement, but it did not wholly prevent the wall from cracking.

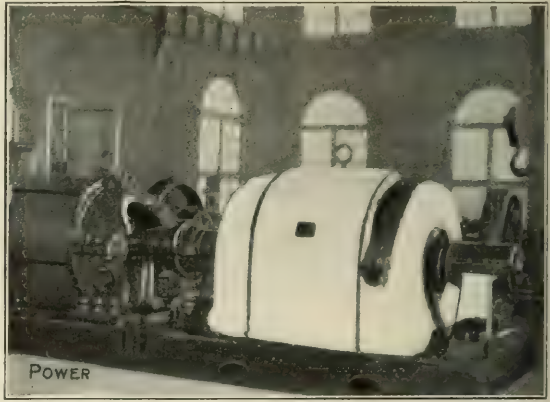
Later on, this wall was taken down to within 2 ft. of the boiler-room floor, and securing two pieces of 8-in. channel iron they were set up, one at each end, as illustrated. Holes were chiseled out of the brick floor to receive the lower ends of these channel irons, and they were cemented in place. Two $\frac{5}{8}$-in. rods were threaded at both ends to receive nuts and were put in place to act like through braces in boiler construction. They were built into the wall, and as the mortar dried and shrunk the nuts were tightened. This was done nearly two years ago, and no cracks have yet appeared.

W. H. Wakeman.

New Haven, Conn.

Frost-Covered Generator

The turbo-generator shown is a 1000-kw. machine, and the windings are cooled by air drawn from outside the power house. At the time the photograph was taken the outside temperature was 26 deg. below zero and the generator was covered with frost, in some places ⅛ in. thick. The dark spot is where the frost started to melt off after a full load for two hours.



Generator Covered with Frost

F. E. Albrecht.

Lisbon, Ohio.

Graphite in Boilers

A. G. James' experience with badly corroded boilers due, in his opinion, to the use of graphite, does not tally with my experience. We use artesian-well water containing a large percentage of lime. I found the three boilers scaled badly and tried different compounds, but obtained the best results by first painting all inner surfaces with graphite, then feeding it daily as directed. The boilers are now thoroughly clean and the inspector has raised the pressure limit 30 lb., on two of them. Mr. James says the corrosion was found at the annual inspection. I have found it good practice to give boilers a thorough internal inspection at least once every three months. It does not look as if all of the blame can be placed on either the "Young College Graduate" or the graphite.

Charles V. Becker.

East View, N. Y.

* * *

Lubricating Engine Bearings

Mr. Crockett's views on lubricating engine bearings, in the Jan. 20 issue, are held by many good mechanics, but I would like to know if he, or any other man, can present a logical reason for cutting such grooves in journal shells as he describes.

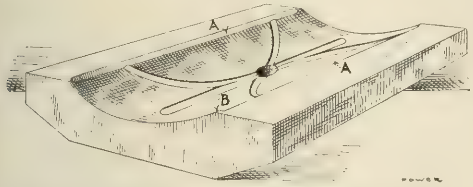


Fig. 1. Grooves in Bottom Bearing Shell

If a journal runs hot it is taken apart and scraped to a fit, and if it happens to be without grooves, deep ones are cut. If the journal runs cool after it is again put in service, the newly cut grooves get the credit, instead of the newly dressed bearing surfaces, which are more likely to have improved conditions. If the bearing still runs hot, no one blames the oil grooves.

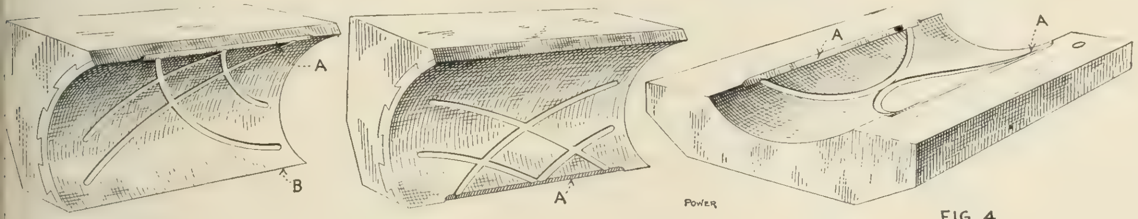


FIG. 2 FIG. 3 FIG. 4

Mr. Crockett's Method of Grooving Bearing Boxes

The first journal I put up without oil grooves was on a belt-driven rotary pump with a 4-in. shaft. Three months later the chief had the caps taken off to facilitate removing a gear. There was one slot cut in the cap engthwise, but none in the bottom shell. He called my attention to the omission and said things not fit for publication. Although he was a capable man, he believed that all bearings should be grooved, and the fact that the bearngs had run cool for a month made no difference to him.

Referring to Mr. Crockett's sketch, if oil were introduced to the top of the grooves in his Fig. 2, if these grooves were connected with those in Fig. 4, and the latter grooves connected with the bottom of the opposite side quarter box, it is possible that oil would flow through them and supply oil to the shaft at all parts of the bearng. With oil fed onto the shaft, and allowing that the grooves in Fig. 2 are always kept full, with steam workng in the crank end of the cylinder, the shaft will be pulled back the amount of the clearance between the shaft and the quarter boxes. This should not be any more than the thickness of an oil film or the shaft will pound.

As the shaft revolves it carries a film with it. Suppose this film is heavy enough to fill the groove shown in Fig. 4, is there any chance that the shaft will pick up oil if the shaft is well worn in the bearing, with a pressure of at least 100 lb. to the square inch? I think not, and if this same film is depended on to fill the grooves shown in his Fig. 3, I will have to be shown. If the shaft is well bedded in the box I would turn the engine one revolution to see where the shaft bearing comes and make it uniform from one end of the box to the other.

The edge *A* of the bottom box, Fig. 1, should be cut away at an angle of 45 deg. with the face *B* to within 3/8 in. of the ends of the boxes. The oil will carry around just as well as if the babbitt were grooved and the area that would have been used for them is left for its real purpose.

There are engines which are overloaded and the bearings heat up no matter how carefully they are fitted. If these bearings are watched before they begin to heat, it will be found that the shaft will come up dry, because the pressure is so great that the oil is forced out from between the shaft and the bearing.

The surest way to oil such bearings is to automatially pump oil into the bottom shell. Oil pumped into the center hole will be forced out into the bearing, due to the pressure being greater than that of the shaft in the bearing. Here I approve of an oil groove, because I can see that it is for distributing oil the length of the bearing, as also do the shelves at *A*.

As for oil holes in crankpin shells, hardly anyone now uses them in center-oiled pins. A flat spot 1/2x1/2-in. should be filed over the oil hole, and grooves of 1/16-in. radius cut in the pin, as shown at *C*, Fig. 5, the grooves running opposite to that of the rotation of the pin from the hole.

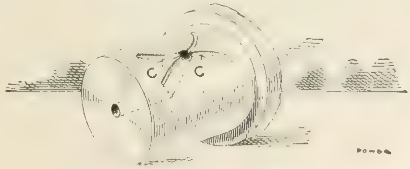


Fig. 5. Grooved Crankpin

I have found can oiling wasteful, dirty and dangerous around a Corliss gear; a grease cup is cheaper and more satisfactory.

S. H. Farnsworth.

Chicago, Ill.

Converting Generator into a Motor

The owners of a machine shop required an additional motor to drive some new machines. A compound generator was found at a second hand dealer's, which he assured them would be large enough to do the work, and could be readily changed to a motor. It was accordingly purchased and installed. The field rheostat was retained and a water barrel provided for starting. The electrician made what he considered the proper connections, and felt assured that they were right when the motor ran properly without sparking or heating with no load.

The moment that load was put on, the brushes sparked badly, the motor emitted groans, came to a standstill and then immediately speeded up in the opposite direction, to the great mystification of all present.

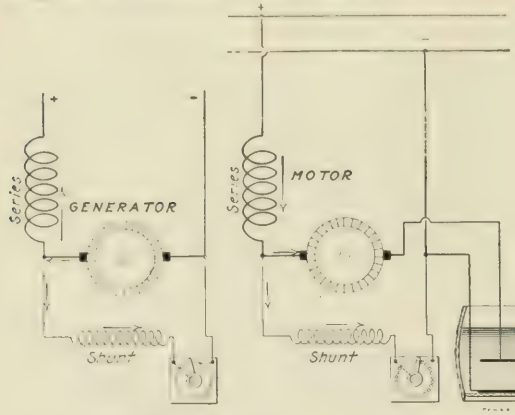


Fig. 1 Fig. 2

Diagram of Connections with Machine Connected as Generator and as Motor

On questioning the man who made the connections, it was found that in the first place, the connections were as shown in Fig. 1. When it was decided to run the machine as a motor, he made the connections, as shown in Fig. 2, neglecting to reverse the series-field connection, which was necessary as will be readily perceived from a study of the diagrams.

Fig. 1 shows the connections when used as a generator. If the direction of current flow is noted and arrows drawn and then compared with Fig. 2, it will be seen that the current in the series winding does not flow in the same direction in both cases. This accounted for the trouble. With the light load the field was entirely due to the shunt winding. Putting on the load increased the current in the series field sufficiently to overcome the effect of the shunt field and caused the motor to reverse. Reversing the series field remedied the matter, as was proved by running the motor with and without load without any further trouble.

As differentially wound motors are not much used, a simple method for determining whether a compound motor is properly connected when no directions are at hand, is to connect it in the usual way, then open the shunt-field circuit, start the motor with the series field alone and note the direction of rotation. Care should be taken not to allow the motor to reach too high a speed, and tests should be made without load. Start up again with both fields connected and no load. If the motor continues to run in the same direction as it did with the series field alone, it is properly connected. If not, one of the field connections must be changed until the armature revolves in the same direction with either field connected.

Another source of trouble after overcoming some of the above obstacles is the question of changing the direction of rotation.

Through ignorance or inadvertence, the shunt field alone will often be reversed to accomplish this, which it apparently does, as the motor will reverse until full load is applied, when the trouble occurs.

The safest and quickest way is to reverse the armature connections, or better still if feasible, move the brush rocker through an angle of 180 deg. in the case of a bipolar machine; 90 deg. in a four-pole, and 60 deg. in a six-pole machine, to accomplish the same result.

P. Justus.

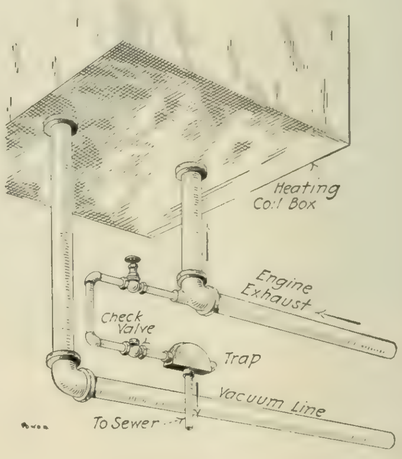
Cleveland, Ohio.

⁂

Home-Made Oil Separator

We had long been troubled with cylinder oil from an engine driving a fan and exhausting into the heating coils. The oil passed through the coils and the return line, and it became serious when it got into the boilers; besides, it formed an undesirable insulation on the inside of the coils.

The plan hinted at in the sketch eliminated most of our trouble. A loop or drop was made in the exhaust line and a home-made trap was attached at the lowest point. As there was a vacuum in the exhaust line at certain times, a check valve was used to exclude air; at others there was a back pressure, so a thermostatic trap such as one sees on radiators was added.



Oil Drain

The device is automatic, requires no attention and discharges oil and water into an open pit almost constantly.

Edward T. Binns.

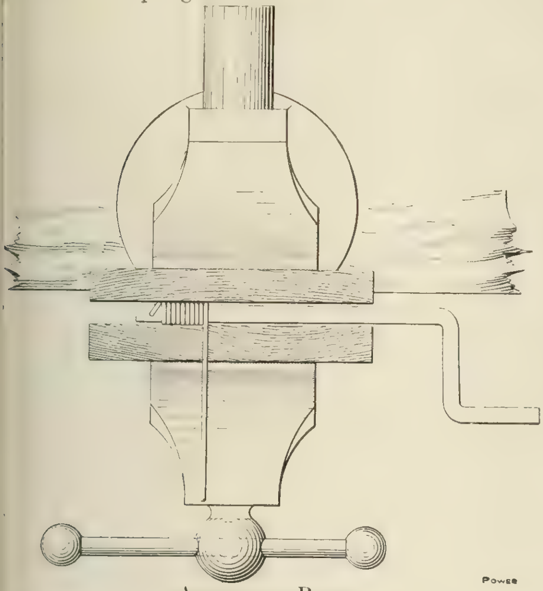
Philadelphia, Penn.

[Since taking out the oil seems incidental rather than functional, this could more properly be termed a thermostatic drain.—Editor.]

Making a Coiled Spring

This may be old to some but I only happened across t lately, and wish I had known it long ago, as it would ave saved time and money.

Take a rod somewhat smaller than the size of the pring desired. Bend a handle on one end and punch or rill a hole through the other end, the size of the wire f which the spring is to be made. Get two blocks of ood, preferably hard wood, and put them in a vise ith the rod between them, and clamp all together firmly. he hole should be a little past the center, lengthwise f the blocks, and in such a position that the wire can be rust into it. Put the wire through the hole, just even ith the other side of the rod, and then wind the wire n the rod by turning the handle. If an open spring desired start the wire winding the desired distance part. If a close spring is desired start it winding close. hen it is nicely started it will make a groove for itlf and all that is required is to turn the handle. This ill make a first-class spring out of quite large wire.



Assembled Parts

A. W. Card.

Winnipeg, Man., Canada.

⁂

Recipe for Metallic Packing

A good cheap metallic packing suitable for nonsupereated steam, air, gas and ammonia may be made as fol-ows:

Melt in a clean ladle the following, which will be sufficient for slightly over 8 lb. of packing:

ead	5 lb.	8.88 oz.
ntimony	1 lb.	0.62 oz.
in		6.25 oz.
ismuth		0.25 oz.

When melted run through a fairly fine sieve about $\frac{1}{16}$. mesh held 9 or 10 in. over the surface of a bucket clean, cold water, this will be found to have split the etal up into small, rough parts of approximately equal ze; of course, the metal will be well mixed in the ladle fore pouring.

After the metal has been taken from the water, dry it and give it a bath in 14 oz. of the best paraffin wax melted in an open top pan with 10.5 oz. of best lubricating graphite.

In packing a gland, first put in a ring of some good, soft packing, then ram the stuffing-box full of the metallic packing and drive it up with a piece of hard wood, finishing off with a turn of soft packing. This packing takes about a day's run to bed up when it will give satisfaction, especially on Corliss valve spindles.

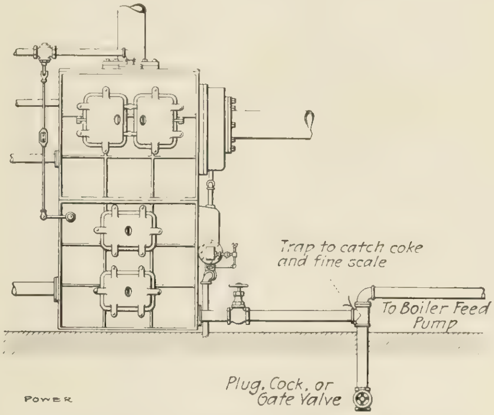
E. R. Pearce.

Rochdale, England.

⁂

Settling Chamber for Filter Coke

A number of the open heaters now on the market use coke as the filtering medium. This often gives trouble by being carried through to the feed pump and lodging under the valves. The sketch shows a way of piping the feed pump to overcome this trouble, the coke falling into the drop leg before it can be carried to the suction chamber.



Drop-Leg to Catch Coke from Filter

Charles Fenwick.

Humboldt, Sask., Can.

[The area of the pipe near the drop leg and of the pipe of which the drop leg is made should be large enough to reduce the velocity of the water through the coke chamber.—Editor.]

⁂

An Oversight

Among the machines in a plant where I was once employed, was a small motor-generator set. In order to make repairs to the commutator, the bearing, of the single-ring oiler type, was removed from the generator end. After the repairs had been made and the machine reassembled, it was started up about 9 a.m. At 3 p.m. this bearing was unusually warm, and in an hour more the temperature had risen considerably.

An investigation showed that the oil ring had been hung up out of the slot in the top box to avoid crushing while putting the bearing together, and had been left there. A stick was inserted through the oil-well cover and the ring pushed down into place; in half an hour the temperature of the bearing was again normal.

John A. Levy.

Greenfield, Mass.

Engineers' Study Course

Elementary Mechanics—III

ANSWERS TO LAST WEEK'S QUESTIONS

6. The resultant of two or more forces is a single force that will produce the same effect on a body as the combined effect of the other forces. The resultant can be found first, by a graphical solution; second, by the use of the general formula for the resultant of two forces; and, third, by resolving the forces into their horizontal and vertical components and using the resultant components as two forces acting at 90 deg. to one another.

7. To solve this problem the student must bear in mind that when three forces act on a body any one force may be considered as the resultant of the other two forces. The pressure exerted by the steam is transmitted by the piston to the piston rod and thence to the connecting-rod, through the crosshead. The connecting-rod exerts a reaction on the crosshead, which produces a pressure between the crosshead and the guides, and this pressure is at right angles to the direction of motion of the crosshead. The thrust in the connecting-rod can then be considered as the resultant of the reaction exerted by the guide on the crosshead, and the pressure of the steam on the piston rod. In Fig. 10, let the length of the line OA represent the load P on the piston equal to 6000 lb. Let OB represent the line of the connecting-rod and ON the direction of the pressure between the crosshead and the guide. The direction of the pressure between the crosshead and the guide is given by ON, but OM represents the reaction offered by the guide. Construct the parallelogram $OABMO$. The diagonal OB will give the desired thrust in the connecting-rod, and its value can be found from the right-angled triangle

$OABO$. As $cos\ 12\ \text{deg.} = \frac{OA}{OB}$

$$OB = \frac{OA}{cos\ 12^\circ} = \frac{6000}{0.978} = 6140\ lb.$$

This problem demonstrates the fact that when the lines of action of three forces are known and only the value of one force is given, the values of the other two can readily be found by applying the parallelogram law.

8. The pressure between the crosshead and the guides is represented by the line ON which by construction is equal to AB, which in turn is the altitude of the triangle $OABO$. In the triangle $OABO$, $tan\ 12^\circ = \frac{AB}{OA}$.

Therefore, $$AB = OA\ tan\ 12^\circ = 129.6\ lb.$$

9. When a force acts on a body its point of application can be assumed anywhere in the line of action of the force. Consider the thrust in the connecting-rod transferred from the point O to the point C, and let its value be represented by the length of the line CF (Fig. 10). As explained in Lesson I, any force can be resolved into components along any desired lines. Hence, resolve the force CF into two components, one at right angles to the line of the crank $O'C$, and the other parallel to the crank. To do this draw the line CS at right angles to $O'C$ and extend the line of the crank to K. Draw the parallelogram $CKFSC$. The length of the line CS will then represent the force tending to rotate the crankpin, and CK will represent the force which, at this instant, produces a tension in the crank.

By construction the angle FCS must equal 12 deg., since CF is parallel to OB, and CS is parallel to OO'. Also $CF = OB = 6140$ lb.

$$CS = CF\ cos\ 12^\circ = 6000\ lb.$$

and

$$FS = CF\ sin\ 12^\circ = 129.6\ lb.$$

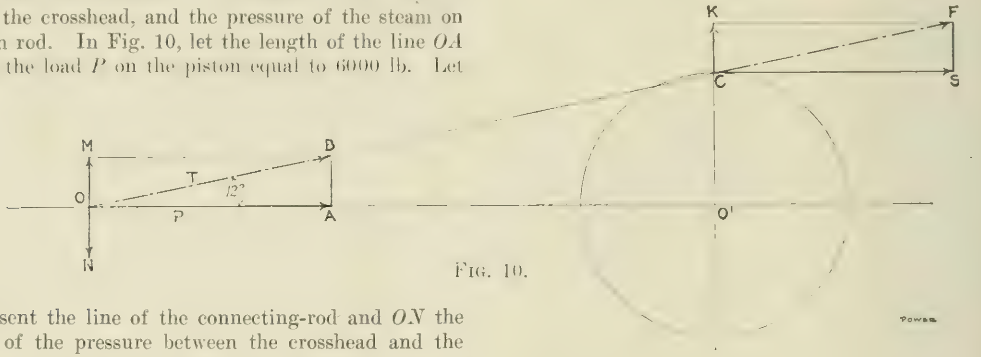


FIG. 10.

10. First make a neat drawing of all the forces acting, representing their magnitudes by the length of the lines (to a given scale) and showing their direction by laying off the necessary angles. Thus in Fig. 11 draw the line OA = 50 lb.; the line OB (making an angle of 30 deg. with the horizontal) = 40 lb.; the line OC (making an angle of 60 deg. with the horizontal) = 60 lb.; and the line OD (making an angle of 120 deg. with the horizontal) = 45 lb. On the forces P_1 and P_2 construct the parallelogram of forces giving the resultant R; in like manner combine R and P_3, giving the resultant R_1; and finally combine R_1 and P_4, giving the resultant R_2. By careful measurement R_2 is found to equal 143.5 lb.

The resultant might be found by resolving all the forces into their horizontal and vertical components.

Thus the sum of the horizontal components is

$$\begin{aligned} H &= 50 + 40\ cos\ 30^\circ + 60\ cos\ 60^\circ + 45\ cos\ 120^\circ \\ &= 50 + (40 \times 0.866) + (60 \times 0.5) - (45 \times 0.5) \\ &= 92.14 \end{aligned}$$

The sum of the vertical components is

$$V = 0 + 40\ sin\ 30^\circ + 60\ sin\ 60^\circ + 45\ sin\ 120^\circ$$
$$= 0 + (40 \times 0.5) + (60 \times 0.866) + (45 \times 0.866)$$
$$= 110.9$$

but $R^2 = H^2 + V^2$

Therefore $R^2 = 92.14^2 + 110.9^2 = 20\,795$

$$R = 144.2\ lb.$$

The value of R is a trifle higher than that found from the graphical solution, but is more accurate.

The direction of the resultant force R_2 is found from the equation. $tan\ a = \frac{V}{H} = \frac{110.9}{92.14} = 1.204$

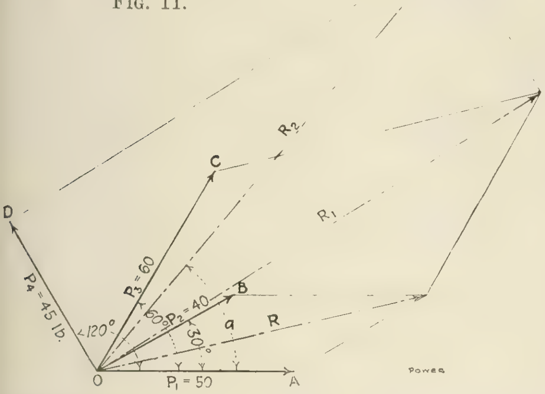
$$a = 50^\circ, 20'$$

Therefore, the resultant force equals 144 lb. and makes an angle of 50 deg., 20 min. with the horizontal.

Free Body

In the problem just solved the student has doubtless noted that no reference was made to the size or shape of the various parts of the steam engine, but only the forces exerted by the various parts were considered. When all the parts of a machine, structure, or body are replaced by the corresponding forces, or reactions, exerted by the parts, the whole is spoken of as a *free body*. In the problem on the engine the wristpin at the point O receives the thrust of the connecting-rod and also the thrust of the piston rod, yet for the solution of the problem it is easier to neglect the source of the force, or the parts transmitting the force, and consider the forces only. Take, for example, a beam resting on two columns, and carrying several concentrated loads. From the standpoint of mechanics the beam, the form of the loads, and the nature of the columns can be neglected, so that the problem would take the form shown in Fig. 12. The reaction exerted by one column has been replaced by a single upward force R_1 at the point B; the concentrated load at D, which might be the weight of a machine or another column, has been replaced by a single force W_1 acting downward; the load C has been replaced by the force W_2 and the reaction of the column A by the single force R_2 acting upward. In the solution of any problem dealing with forces, the student will find his work much simplified, if he will first analyze his problem, then isolate all forces and reactions and solve as if dealing with a free body.

FIG. 11.



Equilibrium

When any number of forces act on a body so as to produce a state of rest, or uniform motion of a body the forces are said to be in *equilibrium* or balanced. An oil can is resting on a shelf. Think of the can as a free body and what is the result? The weight of the can will be replaced by a single force acting downward, while the resistance offered by the shelf, due to its strength, will be replaced by a single force acting upward. These two forces must have the same point of application and be equal to each other but acting in opposite directions. The least number of forces that can produce equilibrium is, therefore, two. Hence *when two forces act on a body to produce a state of equilibrium it follows that these forces must have the same point of application and be equal in magnitude and opposite in direction.* So long as a body remains at rest it is self-evident that the forces are balanced. Suppose, however, a body is in motion—are the forces in equilibrium as before? Take, for instance, a steam engine running at a uniform rate of speed. The pressure of the steam on the piston is just sufficient to balance the load on the engine, and to take care of all friction in the bearings, pins, etc. As long as these forces are balanced the engine continues to rotate at a uniform rate of speed, and will continue to do so unless some of the forces are changed. For example, the least drop in the steam pressure will cause the forces to become unbalanced and the engine will start to slow down; or if the pressure increases the equilibrium is again destroyed and the engine will speed up. Hence the condition of equilibrium of a body, whether at rest or in a state of uniform motion, can only be changed by the addition of an extra force.

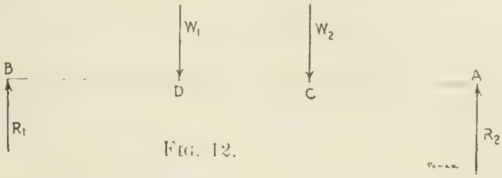


FIG. 12.

What then are some of the conditions of equilibrium for concurrent forces acting in the same plane? Suppose all the forces acting on the body are resolved into their horizontal and vertical components. It must be evident that if there is to be equilibrium of a body the *resultant of all the forces acting on the body must equal zero*, or, put in the form of an equation,

$$R = 0 \tag{6}$$

For the resultant to be zero the algebraic sum of all the horizontal components must equal zero, and the algebraic sum of all the vertical components must equal zero.

Therefore, $$R^2 = \Sigma H^2 + \Sigma V^2 = 0 \tag{7}$$

hence $$\Sigma H = 0 \tag{8}$$

$$\Sigma V = 0 \tag{9}$$

Σ stands for "summation of," or "algebraic sum of."

Study Questions

11. What is meant by the term "free body"?

12. Are the forces acting on a body at rest in equilibrium?

13. Can the forces acting on a body in motion be in equilibrium?

14. State the general conditions for equilibrium for concurrent forces.

15. Make a sketch showing the crankshaft of a vertical side-crank engine as a free body. Assume the engine on the top dead center.

Power Production in the United Kingdom*

By EDWARD G. HILLER

The great bulk of the power in the United Kingdom is generated by steam boilers and steam engines of various kinds, as shown in Fig. 3. It is estimated that there are in the United Kingdom 160,000 steam-generating boilers, apart from railway locomotives of which in 1911 there were 22,841.

As the industries of the country steadily increase in output and in power requirements, so the total power developed tends to increase. This naturally would call for an increased number of steam boilers, but this tendency is somewhat checked as part of the increase of power is provided by gas engines, oil engines, and the like; also that new boilers when put down are generally of greater power than the old ones, so that a less number do the same amount of work. Further, by increased economies in the utilization of fuel a smaller number will do the same work. On the whole, therefore, even with an increasing industrial output the tendency to increase in the total number of boilers will be materially checked.

In Fig. 1 the figures give the approximate proportions in which the boilers of the different classes exist in the country, but do not show the horsepower rating of the different types. They also afford some indication of the changes which are taking place owing to various causes.

The Lancashire boiler was the standard type up to a few years ago, but now in the larger electric-power stations, water-tube boilers are more generally adopted.

The Cornish boiler is generally used only for such industries where it is desired to have an internally fired boiler of less power than a Lancashire boiler. The general proportion tends to decrease.

In recent years the water-tube type has shown more life and movement in production and variety of types than other boilers on land, although on its introduction in Great Britain about 30 years ago it was regarded as undesirable.

It is much easier to design a water-tube boiler for high pressures, such as 200 or 250 lb. per sq.in., than to make a satisfactory Lancashire boiler for these pressures. Therefore movements toward high pressures tend to favor the water-tube boiler.

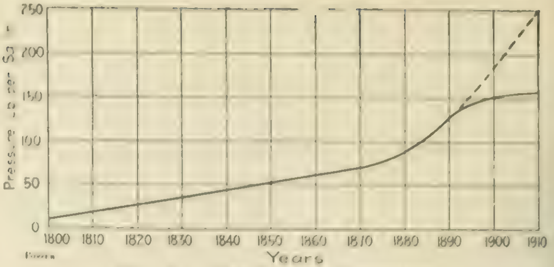


FIG. 2. PREVAILING PRESSURES

In 1890 the capacity of an ordinary water-tube boiler was about equal to one Lancashire boiler, with an evaporation of 5000 or 6000 lb. of water per hour, whereas at the present time in various power stations new water-tube boilers are put down equal to an evaporation of four or five Lancashire boilers evaporating, say 25,000 to 30,000 lb. of water per hour.

The figures show an increasing proportion in point of numbers, and if they referred to growth of capacity, the increase shown would be considerably more, as many of the new water-tube boilers which count only as one boiler have rated evaporations equal to several Lancashire boilers.

The locomotive boiler is one of the most remarkable types in use. Probably if it were today presented for the first time, nearly all engineers of experience would predict that owing to its complexity and rigidity it could not possibly work satisfactorily. It has, however, given satisfaction in various branches of industry and has become practically the standard type of movable boiler on land. At first designed for railways, it continues practically in the same general form as was settled upon many years ago.

The plain cylindrical-type boiler is a rapidly decreasing one. It was one of the earliest, as it is one of the simplest forms of steam boiler. Generally, its disadvantage is that it is short of heating surface, and the external shell, being heated, is subject to various kinds of defects arising from differences of expansion, contraction and the like. To over-

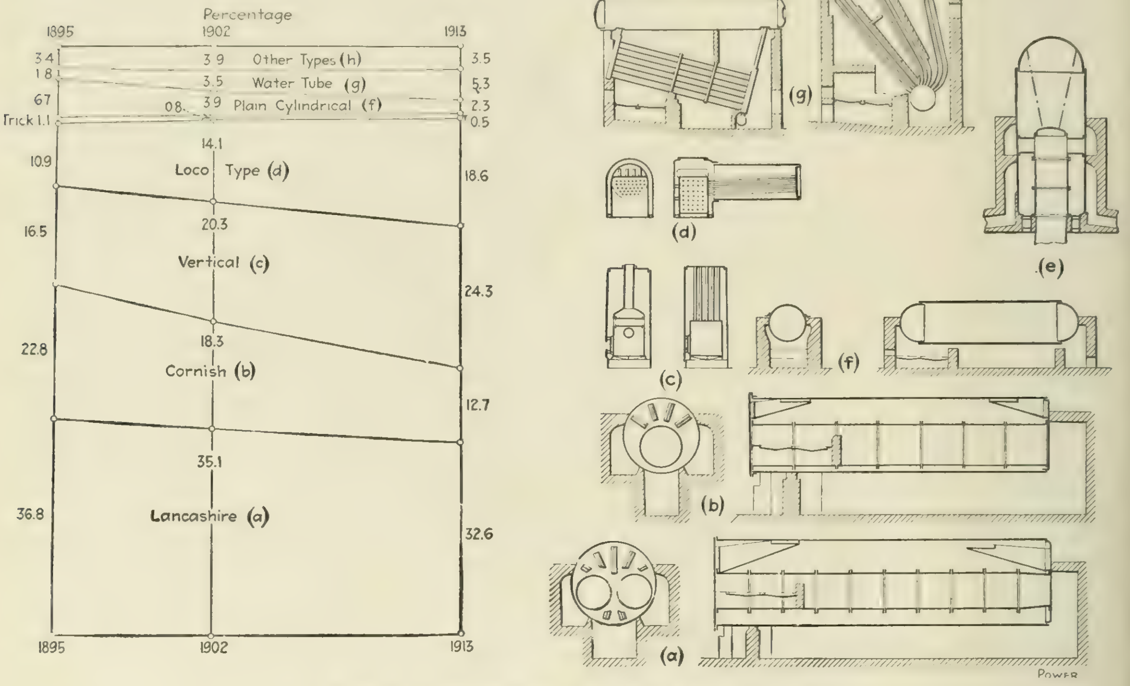


FIG. 1. DIVISIONS IN NUMBERS AMONG TYPES

come the deficiency of heating surface in the old days, increased length was adopted, and with boilers 5 ft. 6 in. in diameter, lengths of 50 to 70 ft. were reached. This great length led to defects and explosions owing to rips at the ring seams. The general realization of the insecurity of this type in the long form has made it obsolete, and few new boilers of this description are being made.

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*Abstract of paper read before the Manchester Association of Engineers, Jan. 24, 1914.

It is notable that the externally fired cylindrical multitubular boiler, the standard low-pressure boiler of the United States, has never obtained any substantial footing in Great Britain. It is a cheap form of steam generator to produce, but it subject to serious risks in working; consequently in the United Kingdom the influence of the boiler-insurance companies has been against this particular type, and has checked or prevented its wide introduction.

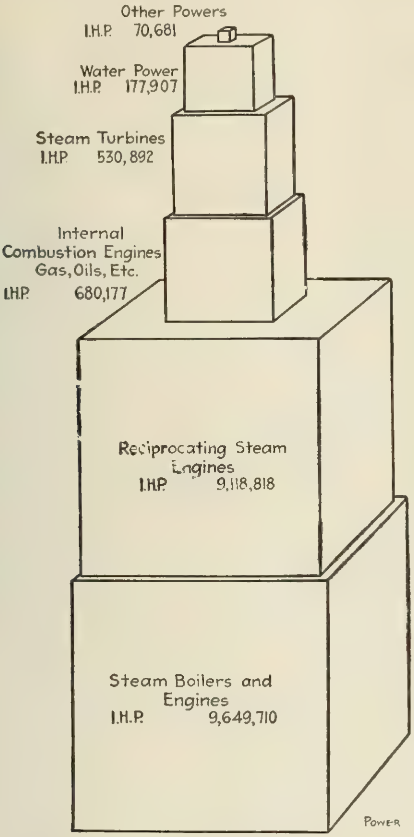

FIG. 3. DIVISIONS OF POWER

The lower line in Fig. 2 indicates approximately the steam pressures generally adopted in the case of Lancashire boilers for textile factories, etc. From about 1880 is to be dated the practical introduction of the modern water-tube boiler, and the upper dotted line in Fig. 2 may be taken as broadly indicating the trend of the maximum pressures in the case of water-tube boilers, as employed for electric-power stations.

⁂

Utilizing Gas-Engine Rejected Heat—The firm of John Cockerill, in Seraing, has made tests to determine the worth of the rejected heat from a gas engine for developing steam for use in a turbine. It was found that practically two pounds of steam of 120 lb. pressure could be made from the heat rejected by the engine for each horsepower-hour developed, and this being used in a turbine requiring 14.3 lb. of steam per kilowatt-hour made a gain of 13½ per cent. in the power developed. The gas engine used in the experiment developed 1250 horsepower. Calculation shows that in an electric station with four gas-engine-driven units of 2500 hp each the cost of the waste heat and turbine installation would be saved in less than two years.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Last week we wrote a weather fling,
Bewailed the Winter's cold and sting,
And longed for balmy, sunny Spring,
"By gosh," we said; "ain't no such thing!"

Now, we're sorry we bawled out Spring
For Winter's now a busted thing,
And sky and earth chuck full of Spring,
It's tough what luck a week will bring.

⁂

They had a mysterious boiler explosion at William Shakespeare, Jr.'s, plant in Kalamazoo recently. Perhaps an enemy hath done this thing. The elder William said some pretty stiff things in his time, but we can't seem to recall that he mentioned Kalamazoo.

⁂

Well, well! Here's Willie Weller who, while fixing a carbon in a lamp on a Pittsburgh street, was overcome by sleep. His spurs were in the pole, his body in the belt. The fire company tenderly took him down and started for the hospital. Then Willie Weller woke and went back to his pole. Willie ought to watch his "lamps."

⁂

Welcome to our midst the brand new engineer—the "rural life engineer!" This feller "goes into rural communities, analyzes their life, pursuits, pleasures and needs; cures defects and builds character by living among the people." What's your home town, feller, we'd like to know you—and ask you how you're making out?

⁂

Our consul at Shanghai suggests that Americans help to establish Western dental schools in China, "thus mitigating much suffering." As a dentist has a hard time trying to be popular, he'd better steer clear of that "painless" brand, and break it to 'em easy.

⁂

This from one we invited to contribute. "As for compensation, we need not worry much; for if I write what I like, on a subject I like to write about, it will not make much difference what the rate of payment is. In any case, whatever I may say will probably need a great deal of blue-penciling and boiling down to be available in the space you can give to such subjects."

This contributor looks at these two questions the way the editor thinks he should. Like Abou-ben-Adhem, "May his tribe increase!"

⁂

A West Virginia reader says: "Ask Billy Spills what he thinks of an engineer who has run a 400-hp. engine for three years and says he doesn't believe in indicators."

Years ago, we were mixed up with the law for saying just what we thought in cold type. We pass.

⁂

There's nothing like knowing what the chap called the pishological moment. Two locomoteers jumped off their engine "at the first sign of the explosion," which is stated to have been when "the crown sheet blew off and the boiler busted." This is going while the going is good!

⁂

Here's a "near" explosion, clipped by friend Standley, Fort Wayne:

"While Smith Bros. were trying to thaw ice out of a pipe connected with their hay bailer, they discovered that the boiler was red hot and no water in it. It is thought that quick work in drowning the fire prevented an explosion that beyond a doubt would have resulted seriously."

Please make your own comment. You have more latitude than we have.

⁂

It's easy enough now to see why those Boston Commercial Engineers are such hearty, jovial good fellows. Their February "Bulletin" says their annual banquet is from Mar. 21 to June 13! Better let up long enough to give the "Power Show" one of your rousing boosts, boys.

The Development of the Modern Central Station

By I. E. Moultrop and W. N. Smith

On Saturday evening, Mar. 14, I. E. Moultrop, at a joint meeting of the American Society of Mechanical Engineers and the Engineers Club of Philadelphia, at the home of the latter organization, delivered a lecture prepared by himself and his assistant, W. N Smith, in which he illustrated with lantern slides a number of the large American central stations, bringing out and commenting upon their particular features.

The development of the alternating-current system of power transmission and distribution began some twenty years ago, and about the first of the large stations to avail itself of the possibilities of the system in location at a point of convenient coal and water supply was the Bay Ridge Station of the Brooklyn Edison Co., built about 1896, and utilizing 6600-volt transmission.

THE STREET RAILWAY LOAD

A tendency to combine the street railway and lighting services has resulted in larger load factors and better conditions for both. The proportion of railway load to lighting and power load in St. Louis is about 40, in Washington about 50, and in Chicago over 50 per cent. of the total central-station output. The New York Edison Co. has lately taken over the operation of the Kingsbridge Station of the Third Avenue Ry., with about 40,000 kw. capacity.

WATER SUPPLY

The importance of the location of the station, with reference to the easy incoming and storage of the raw material, the coal, and of access to an abundant and cheap supply of water, was emphasized. If a station of the size of that of the Edison Electric Illuminating Co., of Boston, lost its condensing water source the city would have to lay a separate water main to supply it. The amount of condensing water required is equivalent to the total water supply of a large city. Numerous slides were shown illustrating the methods of coal storage and handling in various stations.

RATIO OF BOILER AND GENERATOR CAPACITY

In the L Street Station of the Boston Edison Co. there were originally installed eight 500-hp. boilers to one 5000-kw. turbine, or 1¼ kw. of turbine per boiler horsepower. As the station developed, larger sized turbines were used, and with their better steam rate and the modern practice of getting from 200 to 300 per cent. rating out of the boilers, the generator capacity of the station has been increased to 96,000 kw. with a boiler capacity of only 24,000 hp., or 4 kw. per boiler horsepower. At the Northwest Station of the Commonwealth Edison Co. in Chicago ten 580-hp. boilers are used for each 20,000-kw. turbine, giving a ratio of 3.46 kw. per boiler horsepower. At the new South Boston Station of the Boston Elevated Railroad eight 600-hp. boilers were installed to one 15,000-kw. turbine, or 3.2 kw. per boiler horsepower. One additional turbine of 15,000 kw. has been installed since the station was built, and four boilers will be added to the boiler plant, which will make the ratio of actual installed capacity about 3¾ kw. to the boiler horsepower.

At the No. 1 Waterside Station of the New York Edison Co. there are 56 boilers of 650 rated hp. each, making a total of 36,400 b.hp. for an installed generator capacity of 120,000 kw., or 3.3 kw. per b.hp.

At Waterside No. 2 Station there were installed 96 boilers of 650-hp. capacity each, making a total of 62,400 b.hp., for a generator capacity of 93,000 kw., giving a ratio of about 1.50. Since the use of underfeed stokers with forced draft, 36 of these boilers are kept regularly out of service, the ratio of those in actual use to the installed generator capacity being 4.2.*

ARCHITECTURAL EFFECT

Many of the early plants were built without any pretension to architectural effect, but an important public utility building is now expected by the public to be more than utilitarian in appearance. The central power station nowadays is as much of a public institution as a post office, a library, a bridge, a city hall or a national monument, and numerous examples of modern central-station architecture were thrown upon the screen to show how dignity, power and beauty can find expression in central-station architecture.

BOILERS

The water-tube boiler of the Babcock & Wilcox type with superheater is practically the standard for large power construction all over the country. A modification of the Stirling type has lent itself to the construction of the largest unit yet built, 2365 hp., which takes about one-half the cubic space and about one-fourth the floor space per horsepower of the boiler of the usual type. Most of the water-tube boilers for central-station service are built in sizes of from 500 to 650 hp.

Central-station engineers do not yet seem quite ready to adopt units of larger size, chiefly because a larger proportion of boiler capacity will be thrown out of service by a trouble which involves the shutting off of a single boiler. Another reason for keeping to the present standard sizes is the experience obtained during the past few years in running boilers from 200 to 300 per cent. of their rating on the peak loads. Generally speaking, the peaks are of short duration, from one-half hour to two hours, and the efficiency at the greater rating is so little lower for this short period that both the interest on the lower first cost and the saving by banking fewer fires overbalance the small loss in efficiency at the peaks.

PRESSURES AND SUPERHEAT

Station pressures are slowly rising, being frequently 175 to 200 lb., and in the Northwest Station the pressure is 250 lb. Superheat varies from 100 to 200 deg. F., usually the former, and is commonly produced in a superheater located in the boiler itself over the second pass. Boilers usually have the ordinary brick setting. Some engineers have tried inclosing the brick setting in a steel casing, as, for example, at the St. Louis plant. This is done in order to increase boiler efficiency by preventing infiltration of air through the brick work, but results have not yet been convincing enough to spread the practice widely.

MECHANICAL STOKERS

Automatic stokers have been for many years considered a necessary part of central-station equipment, and all the largest stations have them. There are three general types; the chain grate, the overfed inclined grate, and the underfed type. In the Middle West, where much low-grade coal is used, the chain grate, with a long reverberatory arch over it, has proved successful. Chain grates are being tried out in the Northwest Station with two different kinds of baffling. In the East, the other types of stoker are generally preferred, especially where coking coals are used.

FURNACES

During recent years, the municipalities have been enforcing more strictly their regulations about the emission of smoke from chimneys, and it has become necessary for central-station engineers to plan their boiler and furnace installations with a view to smoke prevention. It is now a well recognized fact that combustion can be complete only when the combustion chamber is of sufficient size to permit the combustible matter in the coal to be thoroughly combined with oxygen before the gases are cooled by the boiler tubes. Unless the volatile hydrocarbons can be burned by being forced through the fire, as is the case with the underfeed stoker, furnaces of the Dutch-oven type, or with large combustion chambers are a necessity for the usual type of boiler. [The back ends of the boilers at the Boston Elevated Station are set 8 ft. above the grate, and those at the 201st St., New York, Station, 10 feet.—Editor.]

ECONOMIZERS

The net result of using an economizer is usually not large enough to justify the economizer unless the load factor approaches that of a manufacturing plant, or unless coal is dear, or there is some special reason for needing the storage of a large quantity of hot water to help out the boiler plant.

The extension of the Fisk Street Station, in Chicago, is being fitted with an economizer installation, but on a plan different from that usually followed in past installations, in that there is to be a separate economizer for each battery of boilers, each with its own induced draft fans. In very large stations provision has to be made for the proper admission of the air to the boiler room for combustion, particularly where natural draft is used. The required quantity is so enormous that in order to make the boiler room habitable in winter time it is desirable to handle the air necessary for combustion through the ashpit, and not through the firing aisle.

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*At the 201st St. station of the United Electric Light & Power Co., 36 650-hp. boilers are expected to care for 110,000 kw., giving 4.7 kw. per b.hp. At the Delray station of the Detroit Edison Co., twelve 2365-hp. boilers will serve six 20,000-kw. turbines, giving 4.22 kw. per b.hp. The stacks and breechings have been so proportioned that in emergencies three boilers may furnish two turbines, giving 5.65 kw. per b.hp.—Editor.

STEAM TURBINES

Passing to the generator end of the subject the lecturer showed a slide of the first Westinghouse turbine installed in a central station, that of the Hartford Electric Light Co. in 1901, and of the first 5000 kw. turbine put in by the General Electric Co. at the Fisk Street Station, which was one of the first of its large machines to go into commercial service. After a few years' experience with sizes of 5000 kw. and under, turbine manufacturers began to increase to 7500, 10,000, 15,000, 20,000, and have recently designed a turbine of a capacity as high as 35,000 kw. in a single unit. This increase in capacity has been accompanied by increase in the turbine speed, which has enabled modern machines of very large capacity to be built, but little if any larger in overall dimensions than some of the earlier machines of a much smaller output. At the St. Louis Station the ratio of space occupied per kilowatt is about one to ten in favor of the turbine, as compared to their original engine installation. The 7500-hp. reciprocating engine unit built for New York occupied about four times as much floor space as the equivalent steam turbines and generators which came along later. Nowadays the ratio would be even greater. A 30,000-kw. unit has been designed by the Westinghouse Co. to be installed by the Interborough Rapid Transit Co. in its Seventy-fourth Street Station in New York City. This is being built in two units, the high-pressure to run at 1500 and the low-pressure at 750 revolutions per minute. With 200 lb. steam pressure, 125 deg. superheat and 29 in. of vacuum, a steam guarantee of 11.27 lb. per kilowatt-hour at 30,000 kw. output was given. The Rankine cycle efficiency of the combined units is guaranteed to be 75 per cent. which is said to be higher than for any machine yet designed. This is particularly significant with the vacuum specified.

CONDENSERS

The question of condenser-tube corrosion seems to have narrowed down to a search for an alloy of high heat conductivity, which is not deteriorated by the treatment that it receives during manufacture, and is not subject to local galvanic action between particles of the different metals in its composition; nor by the presence of impurities in the condensing water.

The cooling surface in the condenser of the 25,000-kw. Parsons turbine in Chicago is a little less than 40,000 sq.ft., or 1.6 sq.ft. of condensing surface per kilowatt. This is about 40 per cent. of the cooling surface thought necessary ten years ago.*

AUXILIARIES

Generally speaking, in large stations steam auxiliaries are used, and the exhaust is passed into the feed-water heater. It may be sufficient to heat the feed water to 200 deg., but in very large modern stations the auxiliary steam exhaust is usually sufficient only during times of light load, requiring an extra supply of steam from other sources during the times of heavy load, when the auxiliary exhaust is not increased in proportion.

One method of supplementing the feed-water heaters at peak loads is by bleeding steam from one of the intermediate stages of the main turbine unit.

Pumps and other auxiliaries that can be designed to run at high speed are now nearly always driven directly by turbines, and even low-speed apparatus can now be geared to them. At the new 201st St. station in New York, there are 15 small turbines driving the auxiliaries for three 15,000-kw. main units. Turbine drives are now largely used for boiler feed and for hot-water pumps.

PIPING

The addition of superheat to high-pressure steam has required the substitution of cast steel for cast iron fittings and valves in the main steam line. The early plants where superheat was first installed had to learn this by hard experience, and many rebuilt their pipe lines within a few years of their installation. The valve seats and stems are now usually made of nickel steel, nickel bronze, or Monel metal.

A matter that has received attention in some large stations, and will doubtless receive careful study in all of them, is the installation of permanent apparatus for weighing or measuring water used by turbines, and taking temperatures of steam and water wherever these weights and temperatures can be of use, both in keeping the operating force informed on the day to day or even hour to hour economy in the station, and in making occasional performance tests.

THE BOILER ROOM

The attention of engineers is being directed more and more to securing better economy in the boiler room. This is the point in the station where intelligence in watching and following conditions of boiler operation will instantly result in appreciable fuel economy. For years the electrical end of every station has been completely equipped with accurate and expensive indicating and recording instruments, but it has only recently become the practice to install instruments in the boiler room.

It has been proved by actual experience in Detroit that if men who rank as skilled mechanics are employed as firemen they can be trained to become combustion experts, through their ability to follow the indications of steam-flow meters, draft gages, CO_2 recorders, and similar instruments.

When it is considered that about 60 to 70 per cent. of the cost of central-station operation is fuel cost, the importance of raising the standard of the boiler-room personnel is self-evident.

Recently visual load indicators have been mounted in the fire room to warn the firemen of changes in load. The next instrument to be exploited was the CO_2 recorder. Being a delicate instrument, and one whose operation is not easily understood by the class of help commonly employed in fire rooms, it has to be handled with great care, and has not given universal satisfaction. It is now well recognized that a high CO_2 content of flue gas alone is not the best all-round test for efficient boiler operation, as the samples of the gas may vary widely from different points in the flue.

One of the most satisfactory instruments yet devised for keeping track of steam-boiler performance seems to be the steam flow meter, which, mounted in plain sight on the boiler front, tells the fireman just how many pounds of steam his boiler is evaporating at any instant, and enables him to regulate the fires accordingly.

The automatic regulation of the draft here referred to is not the common damper regulator which is controlled by the steam pressure, but a simple little device mounted alongside the furnace wall consisting of a diaphragm which is actuated by the pressure or vacuum existing in the furnace, the idea being to keep the furnace conditions constant for a predetermined load. This device is useful where forced draft is used, in which case the draft regulator controls the fans or machinery for producing the forced draft, and not the damper in the flue. Drawing a parallel with the electrical instrument, the draft regulator just described corresponds to the voltage regulator on the electrical system, and the steam flow meter to the ammeter.

DRAFT APPARATUS

In the past engineers have felt that the natural draft incidental to the chimneys necessary to carry off the products of combustion was sufficient for the operation of the furnace. At present, however, the need of a more positive control over the draft, and of securing high draft pressure almost instantly to meet some sudden demand, is leading to the general introduction of forced-draft apparatus.

The ideal arrangement seems to be an automatic stoker, which normally runs on natural draft, with some cheap apparatus for materially increasing this draft by putting pressure under the grate to meet heavy peak loads and unexpected demands. Such is the arrangement at the L Street Station, Boston, where, by means of steam jets, boilers are operated for peak work at 300 per cent. of rating.

FEED WATER

In very large stations care is now being taken to keep the feed water pure, not only with respect to solid matter, but also to the alkalies in solution. With the present tendency to force boilers it becomes more necessary to remove the scale-forming ingredients. A bit of scale dropped in a tube where it is exposed to flame, will cause a bulge or rupture in a short time. The purer the water the less frequently will boilers have to be blown down, and the less make-up water will be required.

With feed water that does not require filtration the open type of heater is useful as a purifier, and is for this reason widely used in the Middle West.

Even in a surface condensing plant where the amount of make-up water from outside is a minimum, the open heater is more economical than a closed heater, because all of the heat units in the auxiliary exhaust are utilized by its direct mixture with the steam.

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*A condenser with 25,000 sq.ft. cooling surface will care for a 22,000-kw. turbine in Waterside No. 2. This is less than 1.14 sq.ft. per kw.—Editor.

Half-Million-Dollar Experiment Station

Plans for the proposed $500,000 experiment station of the U. S. Bureau of Mines, to be located in Pittsburgh, Penn., have been approved by the commission appointed by Congress for that purpose. The Federal Government now owns the property upon which will be erected a group of buildings, especially designed and adapted for the carrying on of the mine-safety work and other investigations in which the Bureau of Mines is interested.

Congress, a year ago, authorized a new home for the Bureau of Mines, to cost $500,000. It is now expected that Congress, in its present session, will make a specific appropriation so that construction work may begin. It is hoped that contracts may be let by July 1.

The proposed site consists of nearly 12 acres of land, part of it on the higher level of the city streets and part of it on the level of the Baltimore & Ohio R.R., which will furnish adequate facilities for passengers and freight traffic.

The group consists of the three main buildings. The central building of the group, the mining building, will be three stories in height, flanked by the mechanical, and the chemical buildings. In the rear of these, and inclosing a court, will be the service building. Beyond the service building, and spanning what is known as Panther Hollow, thereby connecting the Bureau of Mines buildings with the Carnegie schools, will be two buildings, over the roofs of which will pass the roadway from Forbes St. to the Carnegie schools and Schenley Park.

The portion of Panther Hollow above the power buildings will be arranged as a miners' field, the slopes of the ravine being utilized as an amphitheater, which will accommodate 20,000 spectators.

The main, or mining, building will contain the administrative offices, and those of the mining force. In it will be an assembly and lecture hall, a library, smoking room and other rooms for demonstrations and training in mine rescue and first-aid. The mechanical building will be for experiments and tests of mining machinery and appliances; and the chemical building for investigation and analyses of fuels, explosives and mineral substances.

The buildings now used by the Bureau of Mines as an experiment station, at Pittsburgh, were loaned by the War Department, as an emergency measure, when the bureau was created.

Dr. Sheldon's 25th Anniversary

On Saturday evening, Mar. 21, at the Hotel Astor, New York City, Manhattan, a dinner was tendered Dr. Samuel Sheldon in honor of his 25 years of service as professor of physics and electrical engineering in the Polytechnic Institute, Brooklyn. About 150 guests were present, including students and alumni of the Polytechnic and men prominent in engineering circles of today.

Thomas Commerford Martin, ex-president of the American Institute of Electrical Engineers, acted as toastmaster. Dr. Fred. W. Atkinson, president of the college, spoke on the life of Dr. Sheldon and his studies abroad. Samuel Owen Edmonds, a patent lawyer of note, told of Dr. Sheldon's work as an expert in several large patent cases. Several interesting reminiscences of the Polytechnic in 1890 were given by William Lord Bliss, the oldest student in the first class of electrical engineering which Dr. Sheldon taught at the Polytechnic. Ralph Wainwright Pope, honorary secretary of the American Institute of Electrical Engineers, spoke reminiscently of many interesting matters, and mentioned Dr. Sheldon's success as president of that organization.

In reply to these addresses, Dr. Sheldon expressed his deep appreciation of the kind thought and feeling which had led to the testimonial banquet. He sketched his experienced career prior to accepting the call to the institute, 25 years ago, and then spoke of the growth of the Polytechnic until today it stands as one of the foremost schools of its kind in the country.

"When I joined the faculty," said Dr. Sheldon, "plans for the new institute building were being made, and courses leading to the degrees of civil and electrical engineers had been determined upon. I was asked to take charge of the development of the latter course in addition to directing the work in the department of physics. Outside of a few civil engineering instruments and some apparatus for the experimental illustration of lectures, there was no laboratory equipment. The problem which the faculty undertook to solve at that time, and which is even yet under consideration, was the elevation of scholastic standards, without the cessation of student attendance and without the expenditure of large sums of money for the purchase of adequate equipment."

The affair as a whole was a splendid tribute to a splendid man. Student cheers and songs under the leadership of Harry Young '11, added to the general enthusiasm. It was a time of good will and kindly feeling.

National Heating Convention

The sixth annual convention of the National District Heating Association will be held in Rochester, N. Y., May 26, 27, 28 and 29, 1914. The program is substantially as follows:

TUESDAY, MAY 26, 2 P.M.

Welcome address, by the Mayor of Rochester, response; president's address; report of secretary-treasurer; appointment of nominating committee; report of underground construction committee, E. Darrow, Indianapolis, Ind., chairman.

Entertainment: For the ladies, auto ride, leaving Seneca Hotel at 3 p.m., and returning at 5:30 p.m.

TUESDAY, MAY 26, 8 P.M.

Report of the nominating committee. Address—R. M. Searle, vice-president, Rochester Ry. & Light Co. Subject, "Public Policy of Utilities." Address, "Manufacture of Welded Iron and Steel Pipe," accompanied by moving pictures showing the progress of manufacture.

At the evening session the ladies will be invited to attend as the addresses will be interesting to all.

WEDNESDAY, MAY 27, 9:30 A.M.

Report of the meter committee, A. D. Spencer, Detroit, Mich., chairman. "Use of Bleeder Turbines in connection with Steam Heating," by R. D. De Wolf, Rochester, N. Y. Election of officers. Report of record committee, A. P. Biggs, Detroit, Mich., chairman.

WEDNESDAY, MAY 27, 2 P.M.

Discussion session. Subjects to be discussed as follows: "Hot-Water Heating under Forced Circulation." "Expense of Operating Centrifugal Pumps vs. Double-Acting Pumps." "Some Effects of Utility Regulation as Affecting District Heating." "Effect of Superheated Steam on Heating Systems." District Heating for Small Towns and Cities of 10,000 Population and Under." "Heat losses from Buildings of Latest Construction." "Which Is More Profitable, to Shut Off Steam at Night or Keep It On Continuously?" "Economic Advantages to Consumers of Central-Station Heating Service Over Individual Heating Plants."

Entertainment for Wednesday: For the ladies, Wednesday morning, shopping tours; Wednesday afternoon, trip on Lake Ontario, returning at 6 p.m. Wednesday evening, theater party for all.

THURSDAY, MAY 28, 9:30 A.M.

Report of rate committee, E. L. Wilder, Rochester, N. Y., chairman. "Customers' Steam-Heating Systems," H. R. Wetherell, Peoria, Ill.

THURSDAY, MAY 28, 2 P.M.

"Commercial Steam Heating in New York City," George W. Martin, general manager, New York Service Co. Report of educational committee, D. S. Boyden, Boston, Mass., chairman. Report of station-operating committee, B. T. Gifford, Grand Rapids, Mich., chairman.

Entertainment for Thursday: For the ladies, Thursday morning, 10:30, card party at Seneca Hotel. Afternoon, auto ride, with tea at Oak Hill Country Club. Evening, for all, informal dance at Seneca Hotel, 8:30 to 11 p.m. For the men, Thursday, 4 p.m., visit to the Taylor Instrument Factory.

FRIDAY, MAY 29

The entire convention as the guest of the American District Steam Co. will go to Niagara Falls on a special Pullman train, via New York Central Lines, stopping en route at Lockport, where the first district heating plant was installed, taking luncheon at the works of the company at North Tonawanda, and spending the afternoon sight-seeing at Niagara Falls, followed by dinner at the Clifton Hotel on the Canadian side, and returning to Rochester in the evening.

The program as outlined is good, and assurances already received indicate that the sixth convention will be the largest attended yet. The entertainment committee has a large fund at its disposal. A cordial invitation has been extended to those district heating stations that are not now members to join the association either at the convention or in advance. There will be a complete exhibit in connection with the convention and applications for space should be made directly to Secretary D. L. Gaskill.

The Seneca Hotel at Rochester will be the headquarters of the association and reservations for rooms should be made directly with the hotel management.

Threaten Rate Reduction at Cleveland

A mandatory ordinance now pending before the city council of Cleveland, Ohio, will, if passed, reduce the Cleveland Electric Illuminating Co.'s maximum rate to residence customers to 3c. per kw.-hr. The ordinance has passed its first reading.

Residence customers are now served under a sliding scale of prices, the maximum being 10c. per kw.-hr. and the average rate earned under this schedule being 6.25c. per kw.-hr. The average lighting bill in Cleveland homes is $1.91 a month. At present the company has no established minimum bill. The general impression seems to prevail among the company's staff that the rate is confiscatory and will not be sanctioned by the Public Service Commission.

*

Old Pumping Station May Be Abandoned

Commissioner Ingersoll, of the Brooklyn Park Department, announces that the pumping station at the foot of Lookout Mountain, Prospect Park, which for many years has supplied the park lakes with water, may soon be closed. William T. Travers, the engineer, recently resigned after 44 years of service. There has been no one appointed to succeed him. The firemen were assigned to other duties in the department.

That the machinery is in need of repairs and new machinery would cost about $7000, is one of the reasons for closing the station.

The artesian well in the pumping station which is considered one of the landmarks of Prospect Park, was sunk by C. C. Martin, the engineer who had charge of the building of the Brooklyn Bridge. The well is 50 ft. in diameter and 50 ft. deep. An iron stairway leads down to its surface, and there are hundreds of callers daily to inspect it. The work of sinking the well was difficult from an engineering standpoint because it had to be built with a coffer-dam.

Since the temporary shutting down of work at the pumping station, the water for the park lakes is being taken from the city reservoirs. The Catskill aqueduct will soon bring an enormous quantity of water to the city, and for that reason the Prospect Park well may never be needed.

BOOKS RECEIVED

ELEMENTAL MAGNETISM AND ELECTRICITY. By C. M. Jansky. McGraw-Hill Book Co., New York. Cloth; 212 pages, 6x9¼ in.; 121 illustrations. Price, $1.50.

APPLICATION OF POWER TO ROAD TRANSPORT. By H. E. Wimperis. D. Van Nostrand Co., New York. Cloth; 125 pages, 4¾x7¼ in.; illustrations; tables. Price, $1.50.

FUEL. By J. S. S. Brame. Longmans, Green & Co., New York. Cloth; 372 pages, 5½x9 in.; 73 illustrations; tables. Price, $3.50.

The Supplymen's Association of the American Boiler Manufacturers' Association announces the completion of its list of boiler, tank and stack manufacturers of the United States and Canada. It is compiled in neat booklet form and contains the names and the addresses of over 900 manufacturers. These books are offered to interested parties, such as tool and material manufacturers for the sum of $3 per copy. Address F. B. Slocum, Secretary, The Continental Iron Works, West & Calyer Sts., Brooklyn, N. Y.

*

Tramway Construction and Material—Proposals are requested by the Direccion General de Obras Publicas, Ministerio de Fomento, Madrid, Spain, for the concession and construction of an electric tramway in Madrid. The American consul at Madrid states that the estimated cost of this tramway is $22,935, and its rolling stock must include at least two electric cars. Work must be commenced within one month from the date of award and finished within three months from the same date. Proposals should be submitted through a resident agent before Apr. 22. A list of such agents can be obtained from the Bureau of Foreign and Domestic Commerce, Washington, D. C.

*

Large Funnels—The last of the four funnels of the new Cunard liner "Aquitania," the largest British steamship, was placed in position in Clydebank dock. The funnel was lifted into place by a 150-ton crane. The width of the funnel fore and aft is 24 ft., and extends above the keel 161 ft. Each one with its section of uptakes and boilers weighs 1500 tons.—"Practical Engineer," London.

Recent Court Decisions

Digested by A. L. H. STREET

Minnesota Boiler-Safety Law—Mar. 3 a jury sitting in St. Paul exonerated the St. Paul Boiler Manufacturing Co. of a charge of having delivered a defectively constructed boiler to a customer. Section 4746 of the Minnesota Statutes, 1913, reads: "Every person who shall construct a boiler or steam pipe of iron or steel plates known to be faulty or imperfect, or shall drift any rivet hole to make it come fair, or who shall deliver any such boiler for use, knowing it to be imperfect in its flues, flanging, riveting, bracing, or in any of its other parts, shall be guilty of a gross misdemeanor, and punished by a fine of $200, one-half of which shall be paid to the informer." A prosecution was instituted against the boiler company under this law, it being alleged in the indictment that the company delivered to one Chas. J. Gustafson a high-pressure boiler, which was faulty and imperfect in its riveting, bracing, and the insertion of gage cocks. It was specifically charged that rivet holes near the firebox door were drifted to make them come fair; that there were no braces from the boiler head and rivets were placed to simulate such braces; and that the lower and middle gage cocks were improperly inserted below the crown sheet. After a vigorous trial of the case for two days, the jury returned an immediate verdict in the company's favor, thus finding that the company established its claim that the boiler was properly constructed and conformed to the warranty under which it was sold that it was adapted to a working pressure of 100 lb.

Legal Status of Public Service Franchises—Suit may be maintained in the name of the state to forfeit a public service corporation's franchise granted by a city, since, in granting franchises, municipalities act as agents of the state. The city is entitled to sue to annul a franchise for breach of its contractual provisions; but the state is the proper party to sue for abuse of the franchise. "It is implied, as the essential condition upon which corporate life and powers are granted to public service corporations, that they shall fairly and substantially perform the functions and discharge the duties for which they have been created. A willful and persistent failure to do so may subject their franchises to forfeiture and themselves to dissolution."

This implied duty is violated by unreasonable discrimination in service or charges to consumers, or by illegal combination with other public service companies. Although refusal of service in particular instances will not ordinarily furnish ground for forfeiting a franchise, they may be considered with other breaches of duty, in determining whether there has been such abuse of the franchise as warrants a forfeiture. (Alabama Supreme Court, State vs. Birmingham Water Company, 64 "Southern Reporter" 23.)

ENGINEERING AFFAIRS

The trustees of Columbia University will raise the requirements of admission to the schools of mines, engineering and chemistry. After July 1, candidates will be required to present evidence of such preliminary general education as can be had by at least three years' study in a college or scientific school of high rank. Candidates for degrees will be admitted to the second year of the present course upon showing evidence that they have completed the work of the present first year in addition to the existing entrance requirements.

The New England Association of Commercial Engineers gave its annual dinner at the Revere House, Boston, on Saturday evening, Mar. 21. About 150 members and guests were present. Mayor James W. H. Myrick acted as toastmaster. The speakers were District-Attorney Joseph C. Pellitier, of Suffolk County, and the Hon. William S. McNary, ex-member of Congress and chairman of the Harbor and Land Commission. John A. Hill, of the Hill Publishing Co., and Jack Armour, of "Power," New York, were also among the guests. A very enjoyable cabaret show was given, and the meeting ended with a stage performance.

*

Oil-Burning Locomotives in India—The Northwestern Railway, of India, has recently built its first locomotive fitted to burn oil as fuel.

PERSONALS

William T. Travers, for 14 years engineer at the Prospect Park pumping station, Brooklyn, N. Y., has resigned. A brief account is given of this old pumping station on another page.

Fred B. Smith has been appointed assistant to President T. F. Manville of the H. W. Johns-Manville Co., New York City.

Walter C. Allen, for the past five years general manager of the Yale & Towne Manufacturing Co., was elected a vice-president of that company, following the annual meeting of the stockholders on Mar. 12.

OBITUARY

EDWIN M. CORYELL

Edwin M. Coryell, consulting engineer, New York City, died from heart disease in his office at 11 Broadway, Mar. 23. He was in his 66th year and had been for many years consulting engineer for the Cameron Steam Pump Works of New York City.

JAMES W. THOMSON

James W. Thomson, chief engineer, U. S. N., retired, died at his home in Moorestown, N. J., Mar. 17. He was born in Wilmington, Del., Nov. 10, 1836. He was appointed third assistant engineer in the United States Navy in 1856, and was promoted until he was chief engineer in 1862. He was retired in 1896 with the rank of rear-admiral.

WALTER LAIDLAW

On Wednesday, Mar. 25, Walter Laidlaw, secretary of the International Steam Pump Co., New York City, died of heart disease while on the way to his office.

Every engineer who had the privilege of personal contact with Mr. Laidlaw honored his unswerving integrity, loyalty and fairness, and respected the ready application of his vast experience and his clear, commonsense consideration of practical engineering and manufacturing problems. Very few, however, knew of his unusually interesting earlier experience and his highly privileged personal associations.

Mr. Laidlaw was born in Scotland in 1849. In his youth he served an apprenticeship of 4½ years as machinist with James Sheil, maker of machinery for the manufacture of Scotch-Tweed, engines, waterwheels, shafting and gearing. This course was supplemented by 1½ years' service as an "imperial erector" with Caird & Co., shipbuilders and engineers, Greenoch, Scotland, where he was engaged in the erection of first-class ocean steamships. He endured the usual hardships and privations of the apprentices of his class at that time, but his interest and ambition were such that in spite of the hard and continuous labor, he heartily enjoyed the service and his opportunity for acquiring knowledge and experience.

He next entered the engineering department of Trinity House, which body has official charge of the lighthouses of Great Britain. He served as engineer and chief engineer for 10 years and worked in this most interesting period of lighthouse development shoulder to shoulder first with Prof. Michael Faraday, and later with his successor, Prof. Tyndall; he also enjoyed the acquaintance and at times coöperation of Lord Kelvin in some of these developments.

Mr. Laidlaw was actively engaged in the design, equipment and erection of some of the most famous British lighthouses. While in this service he drew the specifications for and purchased the first direct-acting generator ever used for lighting, which he installed and for a while operated in the lighthouse at the Lizards, where it is still in satisfactory operation as an auxiliary.

In 1891 he came to the United States and went to Cincinnati, working for a while as draftsman for the Lane & Bodley Co. and then as constructing engineer for Procter & Gamble, Ivorydale, Ohio.

In 1909, he became vice-president and manager of the works of the Laidlaw-Dunn Co., afterward the Laidlaw-Dunn-Gordon Co. During this period Mr. Laidlaw realized the full development of his engineering abilities and became greatly interested in the technical education and advancement of young men, as will clearly be attested by a host of prominent engineers in the Central West. It was largely through his efforts that the Ohio Mechanics Institute was placed upon a solid basis and began its successful expansion. He served at one time as president of the institute and recently stated that one of the most pleasant memories of his life was the privilege of awarding the diplomas to the young graduates in whom he had taken so much interest. Mr. Laidlaw remained a life member of the corporation.

In 1905 he was elected a member of the American Society of Mechanical Engineers. In 1910 he became general manager of the Snow Steam Pump Works at Buffalo, and in 1911 a member of the executive committee of the International Steam Pump Co., for which position his training had eminently fitted him. In 1914 he became its secretary.

WALTER LAIDLAW

Mr. Laidlaw's death was a great shock to his immediate associates and the engineering profession. His modesty prevented reference by him to his earlier experiences and associations, and it is believed this short sketch will be of interest to those engineers who had not previous knowledge of them.

*

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

of Power, published weekly at New York, N. Y., required by the Act of August 24, 1912.

Editor, Fred R. Low, New York, N. Y.
Managing Editor, Henry R. Cobleigh, New York, N. Y.
Business Manager, William Buxman, New York, N. Y.
Publisher, Hill Publishing Company, New York, N. Y.
Owner, Hill Publishing Co., 505 Pearl St., New York, N. Y.

Owners of 1% or more of Stock Issued.

John A. Hill, 505 Pearl St., New York, N. Y.
Fred R. Low, 505 Pearl St., New York, N. Y.
John McGhie, 505 Pearl St., New York, N. Y.
Fred S. Weatherby, 1600 Beacon St., Boston, Mass.
Frederick A. Halsey, 356 W. 120th St., New York, N. Y.
G. Eugene Sly, 50 Union Sq., New York, N. Y.
Frederick W. Gross, 215 E. 11th St., Erie, Pa.
Alfred E. Kornfeld, 114 E. 71st St., New York, N. Y.
Emma B. Hill, 80 Munn Ave., E. Orange, N. J.

The balance of the stock issued (less than 1% each) is owned by 69 employees, 3 ex-employees, and 14 others who are wives, daughters or relatives of employees.

Known bondholders, mortgagees, and other security holders holding 1 per cent. or more of total amount of bonds, mortgages or other securities. Mortgage on building held by Dime Savings Bank, Brooklyn, N. Y.

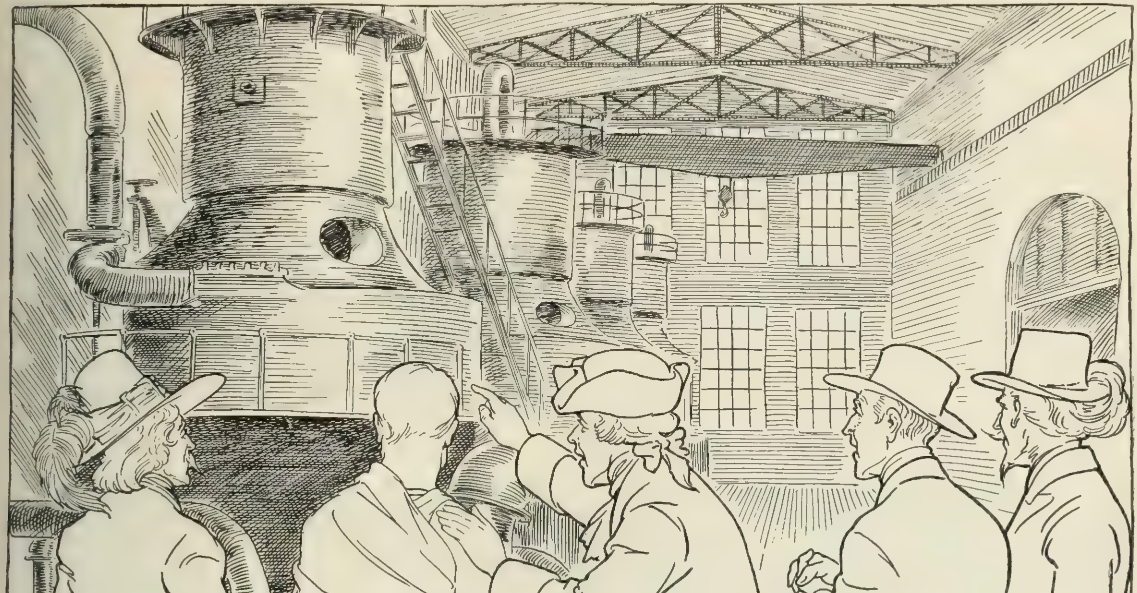
C. W. Dibble, Vice-President,
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 24th day of March, 1914.

RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1915)

POWER

Vol. 39 NEW YORK, APRIL 14, 1914 No. 15



WILL THE FUTURE HOLD AS MANY SURPRISES FOR US?

Busch-Sulzer Bros. Diesel Engine Plant

By Thomas Wilson

SYNOPSIS—An interesting oil-engine plant containing exhaust heaters to utilize the heat in the exhaust gases, a special cooler for the jacket water and a hydraulic oil-handling system.

⁂

The possibilities of the oil engine as a factor in the power-plant field in this country have to a certain extent been demonstrated by the works of the Busch-Sulzer Bros. Diesel Engine Co., in St. Louis, Mo. This company has just completed a million-dollar plant for the exclusive manufacture of the Diesel engine. An immediate capacity of from 10 to 15 engines per month is available and provision has been made for extension as the demand increases. J. R. Harris, vice-president and general manager, and Max Rotter, chief engineer, entered prominently into the design of the entire plant, while the Arnold Co., Chicago, were the engineers and constructors for the buildings and the general equipment.

The present group of buildings occupies about one-half of a nine-acre site located a quarter of a mile from the Mississippi River and in communication with excellent railway facilities. There are a service and an office building, the power house, machine shop, forge shop, pattern-storage building and a U-shaped structure, one leg being devoted to the storage of raw material, and the other to finished material and an erecting and testing floor. The machine shop connects the two, so that the process of manufacture is continuous from raw material to the testing floor.

Considerable power is required by the various machines, traveling cranes and elevators. Individual motor drive with push-button control has been employed, and there are about 150 motors in all, ranging from $\frac{1}{4}$ to 50 hp. They operate on direct current at 220 volts, and are nearly all of the variable-speed type. Tungsten 100-watt lamps are used for yard lighting. 10- to 50-watt lamps are dis-

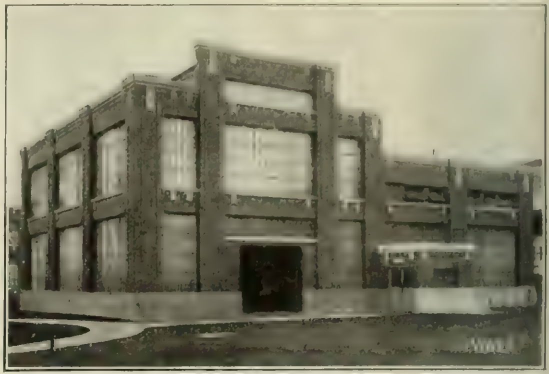


Fig. 1. Exterior of Power House

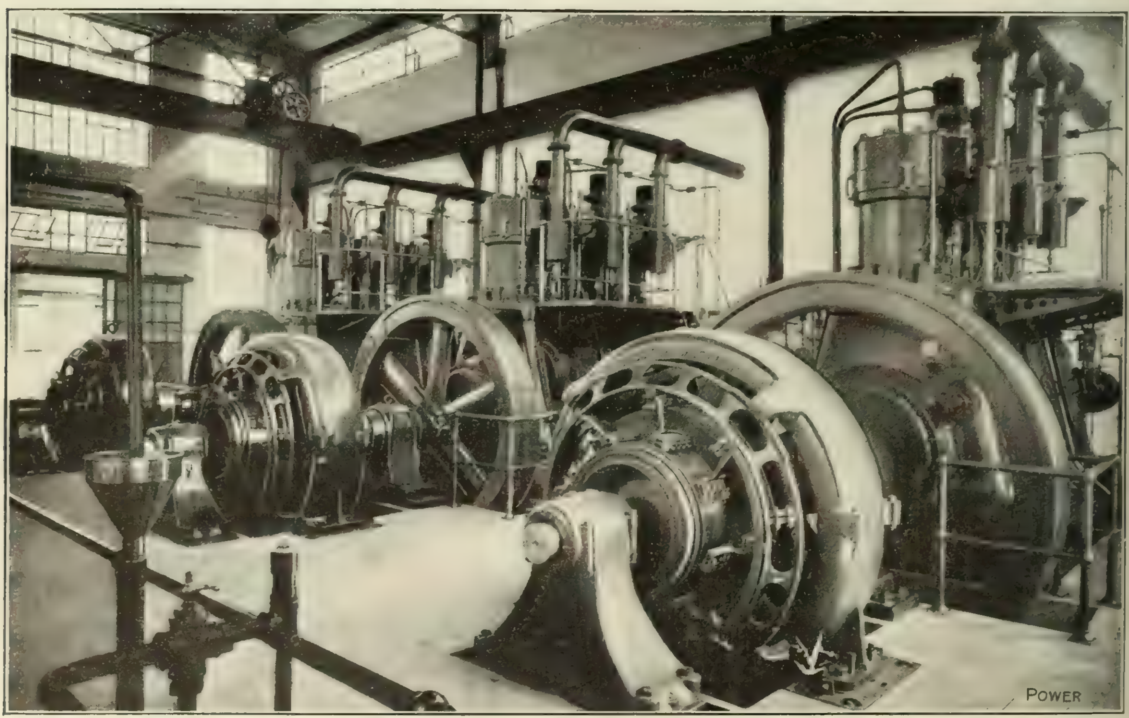


Fig. 2. The Three 225-Hp. Diesel Engine Units

tributed throughout the buildings for special work and for general illumination flaming arcs have been selected. With numerous incandescents in addition to a special watchman's circuit, consisting of 25-watt tungsten lamps, the lighting load should average about 40 kw. Adding to this the average demand of the motors, a total load approximating 400 kw. may be expected.

To supply current for the power and lighting loads, the company has installed an oil-engine plant which is featured by the utilization of the exhaust gases for heating the buildings, a special cooler designed to maintain the engine jacket water below a specified temperature, and a hydraulic oil-handling system. A boiler room may seem out of place in a Diesel-engine plant, but here it was desired to operate a number of hammers in the forge shop with high-pressure steam and to supply some steam to fill in the gap between the heat available from the engines and the requirements during the colder weather, there being 23,000 sq.ft. of radiation. Three 100-hp. Heine boilers to work at 100 lb. pressure have been installed. Oil fuel is supplied through Best burners, one to a boiler, and the products of combustion are carried away through a 3-ft. stack which extends just above the roof. A 90-in. Sturtevant induced-draft fan supplies the air for the three units.

ENGINE ROOM

The prime movers are three 225-hp. Diesel engines, 16x24 in., of the typical vertical three-cylinder type, made by the company. Each is connected to a 160-kw. Crocker-Wheeler, three-wire, 110-220-volt, direct-current generator. Space has been left for a fourth unit of the same size so that the plant will eventually have a capacity of 900 hp. in a room 63x40 ft., which gives 2.8 sq.ft. of floor space per horsepower of rating. At full load these engines will develop a brake horsepower-hour on 0.45 lb. of oil containing 19,000 B.t.u. per lb., or on 8550 B.t.u. As will be apparent in the illustrations, the plant has been laid out on liberal proportions, and care has been taken to secure an attractive appearance. The floors are of concrete with cement finish. A 6-ft. wainscoting of enameled face tile and the piping color scheme (given herewith) add to the general effect. An unusual proportion of glass in the walls and monitor admit the light and fresh air so desirable in an engine room.

COLORS FOR ALL EXPOSED PIPES AND FITTINGS

	Runs	Valves and Fittings	
Water:			
City	Blue	Blue	
Tower .	Blue	Black	
Circulating	Blue	White	Except exposed pipes and radiators in first, second, and third floors of office building, which are to be aluminum paint
Heating.	Blue	Red	
Soda......	Blue	Yellow	
Air:			
Suction..	White	White	Includes ventilating ducts.
Blast—under 5 lb. per sq.in..	White	Blue	
Compressed—100 lb. per sq.in...	White	Black	
Compressed—1000 lb. per sq.in..	White	Red	
Steam:			
Exhaust.	Black	Black	
Live..	Black	Red	
Blow-offs....	Black	Green	
Exhaust gases	Black	White	
Oil:			
Fuel..	Brown	Brown	
Gas:			
City	Yellow	Red	
Drainage:			
Roof drains	Green	Green	Includes all foul water, waste, and overflow pipes connecting to sewers.
Soil pipes...	Green	Red	
Vents	Green	White	
Fire service	Red	White	Includes sprinkler systems, steamer connections, and fire hydrants.
Electric conduits .	Red	Red	

The following shades of the various colors will be used:—

Red—vermilion; blue—prussian; yellow—chrome; green—emerald; white dead white; brown—burnt sienna; black—dead black.

The air required for starting and fuel injection is compressed by two motor-driven, three-stage air compressors, 10, 6½ and 3 by 12 in., and stored at a pressure of 750 lb. absolute in 14 steel bottles arranged along the wall. Each has a capacity of 1½ cu.ft. and one compressor will supply the demands for the day.

COOLING WATER

Cooling water for the engine jackets is supplied from a 1500-gal. tank on the roof. There is a low-level float control which admits makeup water from the city mains when necessary. A 4-in. main brings the supply to the engine-room floor, from which 2-in. taps lead to each engine. From the jackets the water discharges through 4-in. pipes to a common 6-in. main with an outlet to the hotwell and to a rotary cooler installed by the Power Specialty Co. It then flows to a sump and by means of a float-controlled centrifugal pump is elevated to the tank on the roof. Fig. 5 shows the jacket-water and water connections for the boiler-feed and lavatory pumps.

Fig. 7 is an exterior view of the cooler which is a horizontal cylinder 6 ft. 8 in. in diameter and 7 ft. long. The cooling surface within consists of four rotating drums made up of galvanized-steel plates, No. 26 gage, arranged in concentric rings on a cast-iron center and supported from the shaft by steel spokes; a space of about 3 in. separates the drums arranged lengthwise on the shaft. Between the rings of plates there are narrow spaces, so that when the drum revolves in the water at the bottom of the encasing cylinder, thin films adhere to the surface on both sides of the plate. A large surface is thus exposed to the air blown through the cylinder by a fan mounted at the end and discharged through a flue leading to the roof. A small motor rotates the fan and through chain and friction drives also turns the drums. The cooler has a capacity to abstract 2,200,000 B.t.u. per hr. from 5900 gal. of water at 140 deg., when the dry bulb temperature is 85 deg. and the relative humidity 75 per cent. The hotwell, from which feed is taken for the boilers, is maintained at a fixed level, drawing its supply from the jacket water before it reaches the cooler. By this arrangement a considerable portion of the water is diverted and a part of the waste heat in the jacket water utilized.

GAS AND STEAM HEATERS

Evans-Almirall hot-water heating under forced circulation has been installed throughout the shops, which are equipped with 23,000 sq.ft. of radiation, mostly in pipe coils. Either of two DeLaval steam turbine-driven 6-in. centrifugal pumps circulate the water, which is sent out through a 6-in. main dividing into a 5-in. line, supplying the southern group of buildings, and a 4-in. to the northern group. At a temperature of —5 deg. F., of which St. Louis averages about three days annually, the heat loss from the buildings figures 7,250,000 B.t.u. per hr. With the usual drop of 30 deg., 241,670 lb. of water per hour, or about 480 gal. per min., would be required to supply this amount of heat, which would be given up at the rate of 315 B.t.u. per hr. per sq.ft. of surface. The requirements as computed for temperatures ranging from —5 to 55 deg. and the number of days of each temperature are given in Fig. 8. At a temperature of 35 deg., an approximate average for the winter, the heat loss drops to 2,790,000 B.t.u. per hr., a little over one-third of the maximum.

To supply this heat the plant has been equipped with three "Ribbett" cast-iron gas heaters, one for each engine, made by the Williams Tool Co., Erie, Penn. An exhaust-steam and a live-steam heater are also provided, so that the maximum temperature of the water may be attained in three steps. In mild weather the gas heaters will supply sufficient heat, at the average winter temperature the exhaust-steam heater will be needed and in the coldest weather the live-steam heater must be used. The heaters are so piped that any one of the three, or any combination, may be put into service. The water circuits of the gas heaters are arranged in multiple, and one, two or three heaters may act as one unit. The live-steam heater receives its steam direct from the boilers at 100 lb. pressure, while the exhaust from the turbine-driven pumps of the heating system, the boiler-feed and lavatory pumps, and the induced-draft fan engine goes to the exhaust-steam heater. The condensation from the heaters is discharged by a duplex pump into the boiler-feed line through a check valve, with a relief valve opening into the hotwell.

Each gas heater has 200 sq.ft. of surface, and is guaranteed to raise the temperature of 5700 lb. of water from 140 to 170 deg. (equivalent to 171,000 B.t.u.) when the engine is operating at full load and delivering in the exhaust gases 290,000 B.t.u. per hr. to the heater, the temperature of the gases to be 500 deg. With the engine using 0.45 lb. of oil per kilowatt hour at 19,000 B.t.u. per

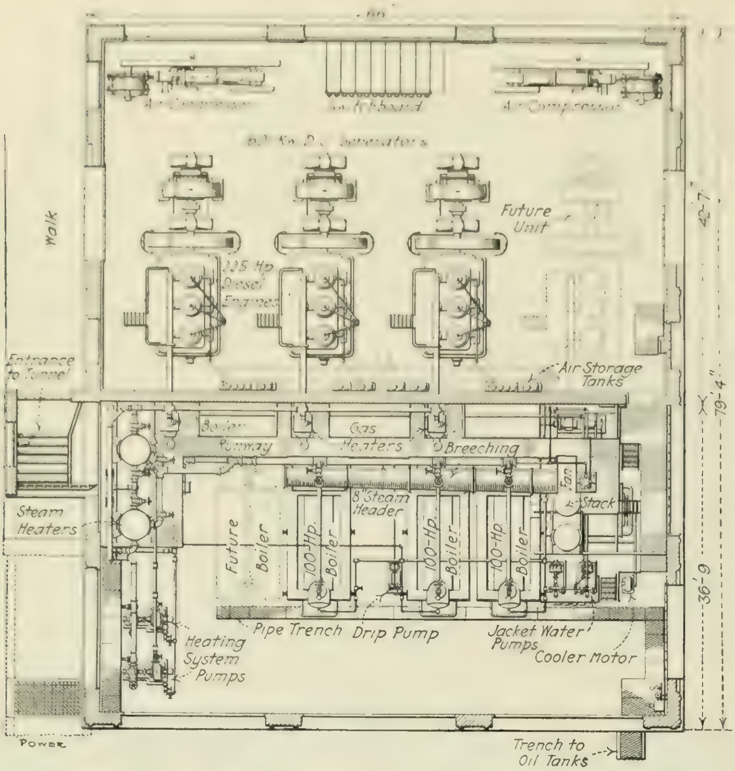


FIG. 3. PLAN OF POWER HOUSE

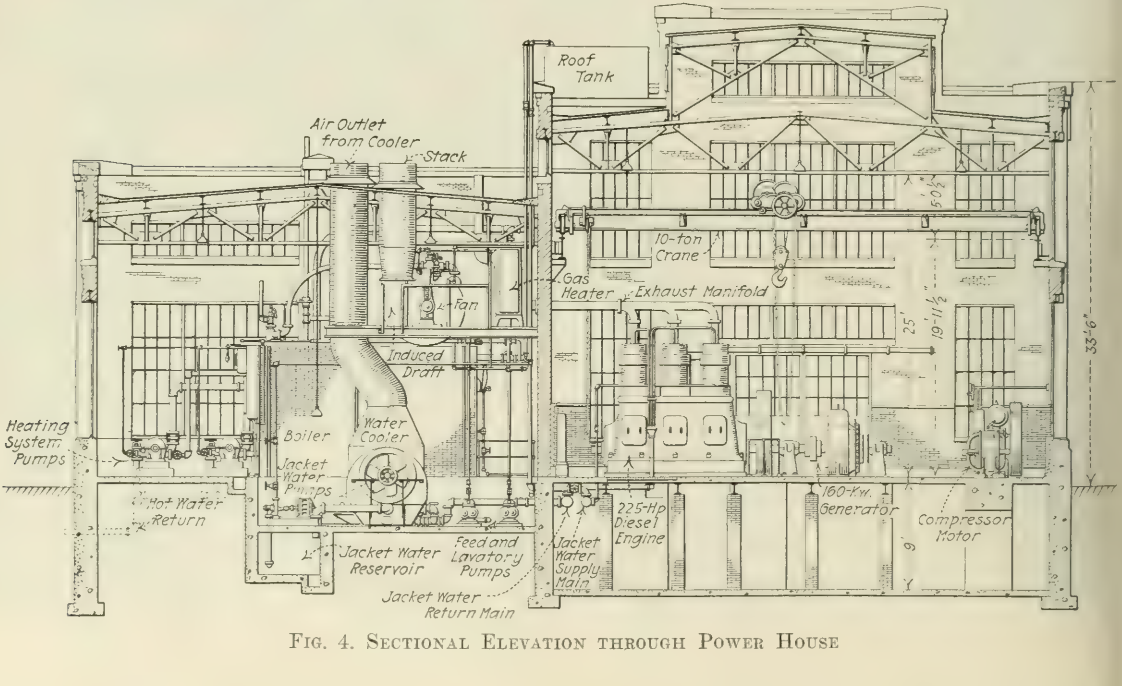


FIG. 4. SECTIONAL ELEVATION THROUGH POWER HOUSE

lb., the 290,000 B.t.u. is about 15 per cent. of the heat in the oil, and of this the water passing through the heater abstracts about 171,000 B.t.u., or 60 per cent., which is equivalent to about 9 per cent. of the heat delivered to the engine. The three heaters would then give to the water 513,000 B.t.u. per hr. The gas is conveyed through an 8-in. pipe to each heater and is discharged through a flue leading to the roof.

Reference to the foregoing paragraph and to Fig. 8 will show that the gas heaters will supply sufficient heat for the shops in weather averaging 55 deg., of which there are 40 days during the heating season. At the average winter temperature of 35 deg., they will supply about 20 per cent. of the demand, and the exhaust heater will just about care for the other 80 per cent. Below 35 deg. it will be necessary to cut in the live-steam heater, using just enough steam to raise the water to the temperature required.

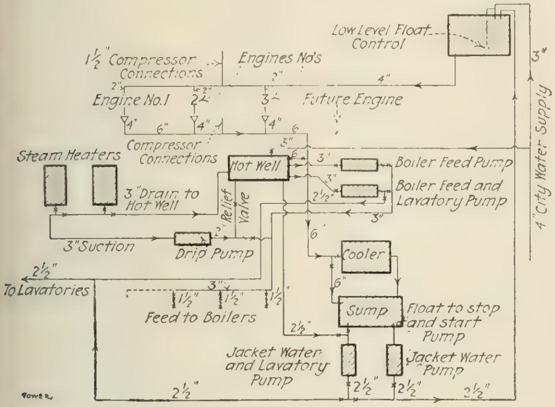


Fig. 5. Layout of Water Piping

Oil Supply

The plant has storage capacity for 60,000 gal. of oil made up of five 12,000-gal. tanks 8½ ft. in diameter and 32 ft. long. The tanks are encased in concrete and have their tops 2½ ft. below grade level. Three of the tanks are about 300 ft. south of the power house near the testing pit and the other two are back of the boiler room.

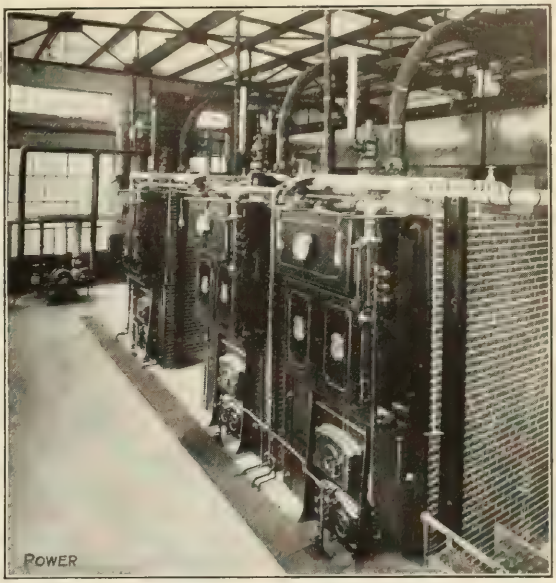


Fig. 6. Boiler Room

The oil is delivered in car shipments to the three tanks near the testing pit, where oportunity is afforded for testing before it is transferred by a small rotary pump to the tanks near the boiler room. Oil for the engines and boilers may be drawn from either tank or the same tank. It is supplied through separate lines with a meter on each to measure the consumption. The oil reaches the burners of the boilers under a head of about 4 ft. and in the engine room is delivered to an auxiliary tank 8 ft. above the floor level, from which it flows to the oil pumps on the engines.

A hydraulic system has been installed to handle the oil in the plant. In operation, this system depends upon the difference in specific gravity between the oil and the water. A column of water connected to the bottom of the oil-storage tank forces the oil to the point of demand, the pressure at the delivery end depending upon the height to which the column is carried. The principal elements of the system are a control valve to turn on the pressure

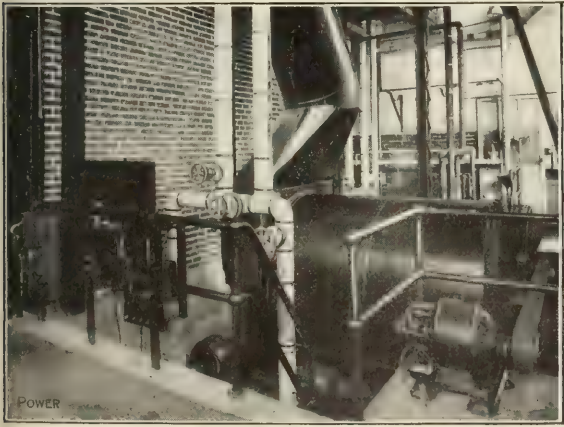


Fig. 7. Jacket-Water Cooler

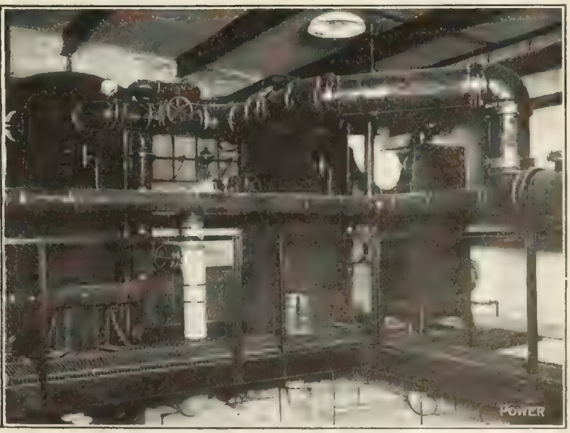


Fig. 9. Gas and Steam Heaters

and a float box connecting with the city mains to insure a constant head.

To prepare the system for operation the lever of the water control valve is raised. This closes the port leading to the water-discharge valve and opens the port leading to the water-float box, so that the water can flow down through the leg at the bottom of the storage tank and up into the tank itself, where a deflector spreads it evenly. The water rising in the tank forces out the air ahead, and its appearance in a gage-glass indicates that the tank is full and that all the air has been expelled. The lever is then dropped, closing the port to the water-float box and opening the port communicating with the water-discharge pipe. This allows the water in the pipe above the water-controlling valve to return to the storage tank and discharge an equal volume of water to the sewer.

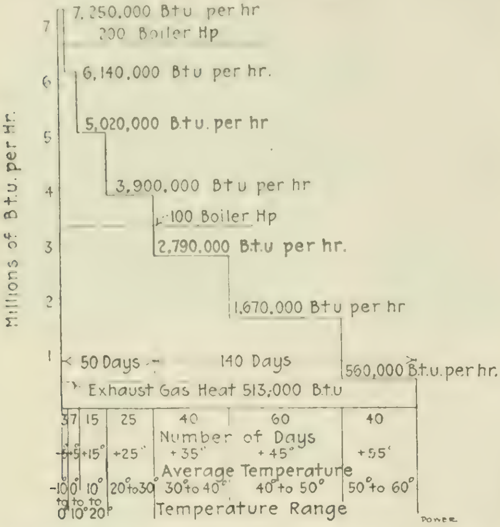


Fig. 8. Estimated Heat Losses from Buildings

Having been freed from air, the system is then ready to receive oil. This is introduced into the top of the tank and a deflector spreads it evenly over the surface of the water. The oil forces the water out of the tank through the water pipe and water-controlling valve to the sewer until the column of water from the control valve down, balances the oil column and prevents further admission.

To start the flow of oil toward the points of consumption, the lever of the water-controlling valve is again raised, closing the discharge port and opening the port to the float box. Water then passes into the tank under the oil and forces it out of the top of the tank to delivery points. Up to the control valve the column of water balances the oil column, so that the head from the control valve up to the water level in the float box is the factor controlling the pressure at delivery. In the present plant this head is about 42 ft., representing a pressure of 5 lb.

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To Electrify Selkirk Tunnel—Westinghouse, Church, Kerr & Co., Montreal and New York, have been retained by the Canadian Pacific Ry. as engineers to investigate the matter of the proposed electrification of the new double-track, 5½-mile Selkirk Tunnel in British Columbia. The investigations will cover in general the type of system to be installed, the relative economies of steam and water power and the effect of the electrification upon operating conditions.

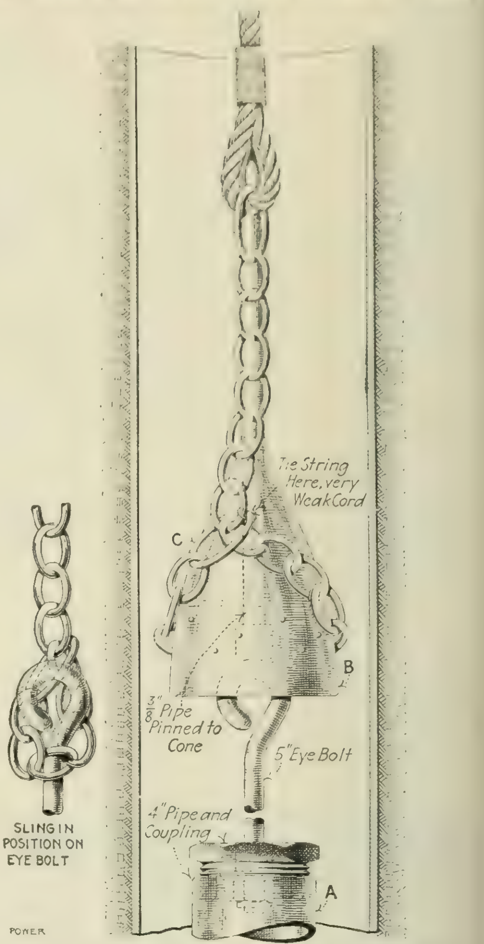
Fishing for Pipe in Deep Well

By Edward O. Johnson

The writer was called upon to fish a 4-in. pipe about 70 ft. long from a well in which it had fallen, owing to poor tackle used for lowering the pipe into the well.

The top end of the pipe was fitted with a coupling and a bushing *A* screwed in tightly as shown. Through the hole in the bushing was a ⅝-in. eye-bolt swiveled to allow screwing the pipe on the piece below. Just how much of the tackle remained in the well was unknown, for the drop was so sudden that nobody seemed to remember just how the tackle looked.

However, since we could not find it outside the well, we concluded it was in the well. We fished for a few hours and finally hooked on something that felt like an eye-bolt. Finding it was fast we prepared for the final task of getting the 70-ft. length of pipe up the long lift. From the surface of the ground to the water was approximately 30 ft.; the top of the pipe was down 20 ft. further. We coupled three lengths of ⅜-in. pipe and made a cone *B* of wood small enough to go in the 8-in. casing and leave an annular space around it of about



Showing How Sling Was Slipped over Eye-Bolt of Well Casing wo inches. The under side of the cone was hollowed ut and the outer surface sheathed with strips of tin.

A short piece of chain with a ring *C* was used as a ling and secured to a rope for hoisting. The sling was ied open by a weak piece of cord, which was designed to reak when the rope holding the chain was jerked. First he wooden cone and pipe were let down carefully until e were sure the cone was directly over the eye-bolt and esting on it. We then let down the sling tied open and ery carefully (lest we should break the tie string) felt it stop at the cone. Gently we forced the sling in over the cone until it was again going freely down the well. When it had passed the top of the pipe a foot or more a sudden jerk was given to the sling in the hope of breaking the tie string, thus allowing the ring to slip over the chain and close the sling.

The third attempt to grab the eye-bolt was successful, and the way that sling adjusted itself and held could not have been better had it been put on by hand. This method is practical in emergencies.

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Packing for Hydraulic-Elevator Valves

By R. A. Cultra

YNOPSIS—A description of a method of renewing cup athers on pilot and main hydraulic-elevator valves. Also he manner of making the leather packing cups at the lant.

⁂

Most pilot and main valves of hydraulic elevators are acked with pressed-leather cups or rings of suitable hape. These valves resemble the piston valve of a steam ngine. They have two disks on each end of a short pindle. A cup is fitted over each inner disk, and is held ght by the outer disk, as shown in Fig. 1. Some of these alve spindles require skill in putting on the leather packngs, especially where the disks are screwed on the stems, nd held tight by nuts, lest the position of the disks on e stem or the distance between them be changed.

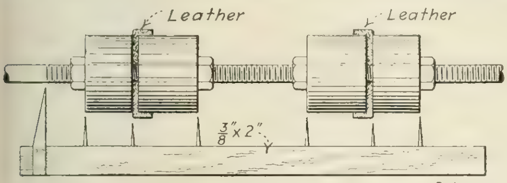

Fig. 1. Pilot Valve and Gage

Lengthening or shortening of this distance will cause he valve to leak or fail to open to the full port opening, hich will cause the main valve to be slow in responding. f the pilot valve leaks, the car is apt to start and enanger the passengers and operator.

It is good policy before removing the old leathers from e disks to take a piece of 3/8x2-in. board, the length f the valve, and mark on the edge the exact position of e disks. Then drive small nails or pins in the edge of e board and file off sharp. This makes a gage, which n be preserved for future use, and the disks can be relaced in their exact position with the leather cups beveen them on each end and screwed up tight, as illusated in Fig. 1.

Both pilot and main valves may be constructed in the anner as described. There are also both pilot and main lves having the two inside disks cast in one piece with a ole through the center through which the rod passes; th disks are machined so that the distance between em is such that the disks will cover both ports in the lve case. This type of valve is less liable to be misljusted when renewing the leather packings, as it is only necessary to remove the locknut and one follower disk on one end of the spindle and the two center disks can be slipped off the spindle without disturbing the locknut and follower disk on the other end.

The leather cups for packing can then be put on the stem and the disks replaced in their original position with little risk of getting them out of adjustment, even if the gage is not used.

There is a slight variation in the space allowed between the valve piston and the casing for the leather cups to fill and care must be taken to have the leather of the right thickness. If they are made of too thin leather, although they may be a nice fit, they will wear away quickly; if too thick it will be hard work to replace the piston in the valve case and there will be danger of cutting the leather cups on one side.

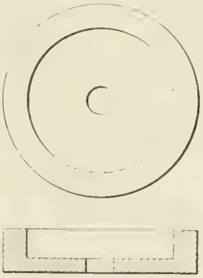

FIG. 2
BOTTOM-HALF OF DIE

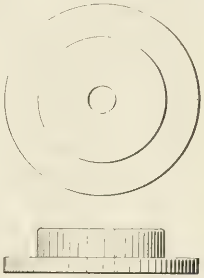

FIG. 3
TOP-HALF OF DIE, BOTTOM UP

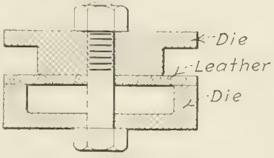

FIG. 4 LEATHER SET IN DIE READY TO BE PRESSED

FIG. 5
LEATHER CUP

FIG. 6
SIDE VIEW OF LEATHER CUP

This difference in the thickness of the leather from which the cups are made is generally the cause of misadjustment in reassembling the piston. Leather disks can be obtained from the manufacturer, but these are not always satisfactory, as they are usually hard and dry, vary in thickness and if allowed to stand in stock for some time, will frequently crack, and become unfit for use. But if they are of the proper thickness and in good condition they can be soaked in luke warm water and put in place. They will generally wear well because the fiber of the leather has been compressed in the making, but are hard to enter into the case on this account.

Some engineers prefer to make the cups and rings, as the stock can be picked and they are not pressed quite so hard, are flexible when used and, as the leather is selected of the right thickness for the cups and rings, there is little trouble in entering the pistons into the casings.

To make these cups a special die for each size and some form of press to shape them is required. Fig. 2 is the bottom half of such a die; Fig. 3 is the top half.

The leather is cut into disks enough larger than the cylinder to give depth to the cup. A bolt is passed through the center of the die. The leather is soaked in luke-warm water and placed between the dies as shown in Fig. 4. The bolt is then tightened, drawing the two halves of the die together, which presses the leather into the shape of a cup. It is allowed to stand long enough for the leather to partially dry and assume its shape.

Fig. 5 shows the leather after being pressed into cup shape. Fig. 6 represents the shape of the leather, looking at it edgewise.

It is not always convenient to press the leather with the bolt as illustrated in Fig. 4, but it can be done if no better means are at hand. A bench vise can be used to good advantage for pressing the die together and much time and labor saved by its use.

* * *

Modern Boiler-Room Practice*

By Charles H. Bromley

SYNOPSIS—Deals with heat losses due to excess air. Sources of excess air. Finding the correct draft and depth of fuel bed for given loads. Limits of the duties of firemen. Poor and good practice in flue-gas sampling. Soot troubles. Large furnace volume allows of more complete combustion of high volatile and therefore cheap coal; high combustion rates may be had with the fine grades of anthracite without it being carried over the bridge-wall. Most manufacturing plants needlessly suffer heat losses due to running boilers below rating. Furnace heights and ratio of boiler to kilowatt capacity as practiced in large plants. Hints on purchase of coal.

*

This subject is so broad that I can hit only the high spots in a single evening's talk.

Consider a boiler as something of two distinct parts, a furnace where combustion of the fuel takes place to produce heat, and a shell containing water to absorb that heat and furnish steam. Successful boiler operation lies in getting as much of the heat in the fuel into the water in the shell as is practically possible. Consider the two parts of a boiler as distinct, because you may have the best possible furnace efficiency while the heat-absorbing efficiency of the heating surface may be extremely low, due to scale and soot accumulation.

EXCESS AIR

If, in filling a 10-quart pail from a faucet, part of the stream ran on the outside of the pail, more than 10 quarts of water would have run from the faucet when the pail was filled. That which did not go into the pail would be excess water. Theoretically, 11.6 lb. of air is required to burn 1 lb. of coal. Practically, 20 to 24 lb. is needed. The difference between 11.6 lb. and 24 is the excess amount—excess air. As boiler-room practice goes, the excess air admitted to the furnace may be, and generally is, 50 to 400 per cent. From 25 to 45 per cent. excess air must be admitted to the furnace to obtain complete combustion and the heat it is possible to produce.

The greatest of the heat losses result from the following causes: Too much air admitted, even though it is well mixed with the gases, as when the draft is too strong for the thickness of the fire or the fire has "holes," or when there is much leakage of air through the setting at the first and second passes. The draft may be correct for normal conditions, but owing to the presence of a proper combination of iron, silica, lime, sulphur and clay in the fuel, the coal may clinker and slag, stopping the admission of the right amount of air through the grate. Then CO instead of CO_2 will form and about only one-third of the heat will be obtained from the same amount of fuel as would be obtained if it were burned to CO_2.

As for draft, we are interested chiefly in the volume of gases passing over the heating surface, because on this depends, almost solely, the rate of steam production, provided we have apportioned the air supply correctly and the boiler is clean. Therefore, for a given fuel and grate we can determine the thickness of fire and the boiler draft (pressure difference between the furnace and uptake) that will give the best results for a given load. This condition of fuel bed and draft must be determined for each load condition on each boiler.

Coals of different constituents require different amounts of air. Every shipment of fuel varies in quality and constituents. To save being on his feet too much the fireman covers the fire too heavily. Many firemen turn the fire upside down and mix much ash with the white-hot coal every time they use the slice bar. The ash melts and by the time it reaches the grate it has cooled and formed slag and clinker, increasing the resistance of the fuel bed. This fire is not attended to because the clock does not say it is time to do so. This boiler loafs and wastes fuel. The other boilers are worked harder to carry the load and this condition prevails until cleaning time by the clock, not by the state of the fire. Here is where a steam-flow meter serves well as a check on the work of the boiler.

Every fireman should understand that just as much fuel can be wasted by excess air coming in through uneven and too thin fires as through an open furnace door. Too much air is too much, no matter where it comes in.

LIMITS TO DUTIES OF FIREMAN

Too much is expected of the fireman. His duty is well done and ends when he maintains the correct height of, and a level, even burning fire, regulates the draft to suit the load and fuel conditions, maintains a uniform water level, and keeps soot out of the boiler. Finding air leaks in the setting with a torch or candle and stopping them with cement or waste and fireclay, determining the proper height of the fire and correct draft for the load conditions, is the engineer's job. You cannot fire boilers with a template. The fireman must use some judgment, but the fuel and load conditions in nearly every plant admit of finding what furnace adjustments are needed. Find what these adjustments are by closing all air leaks in the setting and its doors and the boiler headers, and analyzing for CO_2 until the thickness of fire and draft is found that will produce the highest CO_2 and still make the boiler do its share of steam making.

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*From a lecture before Newark, N. J., N. A. S. E., No. 3.

Hold the fireman to these adjustments. You must rely on him to care for the slight exceptions to the routine you have laid out for him, and you should check his day's work by CO_2 analysis or charts and by recording the coal and water used.

In the 201st St. station of the United Electric Light & Power Co., New York City, the boiler settings are incased in steel with insulation between the brickwork and the steel. These casings cost a lot of money, but the saving in heat losses by radiation and infiltration of air is expected to pay for them and earn money on the investment, as interest is paid on bank deposits.

If the settings are scraped and painted, first use a thin mixture of fireclay or cement, or preferably both, and let the bricks soak in all they can. If an asphaltum-base paint is used, be sure to get one that will not run at the temperatures dealt with. Asbestos board covered with canvas and painted makes a good final covering if cared for properly.

CO_2 Recorders

Any CO_2 recorder is a delicate instrument, and to prove successful must have one or two responsible individuals to care for it. In too many plants this person is a boiler-room helper, an oiler or the fireman, or all jointly take a hand in "getting it going." The engineer is the one properly responsible. He should instruct one or two firemen or an oiler how to care for it, but should not leave the machine solely in their hands until he is sure that they are competent.

I think it poor practice to have one single recorder piped to a number of boilers unless the valves which put the machine in connection with any boiler are housed and locked. Even then the fireman can discover easily to which boiler the machine is connected by manipulating the furnaces, one at a time, meanwhile watching the recorder for marked variations in the reading. This connected boiler will then be made to loaf on the line, the damper and fire being regulated to produce high CO_2. The gain due to driving the other boilers harder is offset usually by the losses occasioned by the loafing boiler.

The valves controlling the water inlets and outlets of gas-sample collectors should be locked to prevent false samples being collected. If unlocked, a fireman can fire badly nearly all day and at the end of his shift produce high CO_2, fill the collector with water, get an instantaneous sample while the CO_2 is high and be credited with an excellent day's work.

It will be found expedient to provide a shelf for the gas analyzer at the collector and draw gas from the collector direct instead of using cumbersome bottles to contain the gas.

Soot

Soot works a threefold harm. It lowers the heat-absorbing efficiency of the heating surface; it obstructs the gas passages through the tubes which necessitates more draft for a given steaming rate; it contains more or less sulphur, and if the soot gets wet from leaks, sulphurous and sulphuric acids are formed, causing corrosion of the tubes. The day will come when permanent soot blowers will be installed with every boiler just as stop valves are installed.

Stoppage of gage-glasses and blow-off pipes must be guarded against as the former trouble has caused some disastrous explosions.

Furnace Volume

It seems strange that after all which has been said of the value of high settings, or large furnace volume, there should be so few in new boiler installations. The only loss is that by radiation and air infiltration, which is negligible, as both may be reduced to a minimum. Combustion will be complete before the heating surface is reached, and high furnace temperature, which is most essential to economy, may be maintained. The volatile combustible, containing so much heat, will give that heat instead of forming smoke and soot. Highly volatile and cheaper coal may be used to advantage. Slow gas velocity in the furnace with comparatively high combustion rates is possible, and fine coal may be burned without a large percentage of it being carried over the bridge-wall or to the tubes and the stack. It is a fact that "soot" taken from back of the bridge-wall has had a heat value of as much as 12,000 B.t.u. per pound. The cost of high settings, and possibly of higher buildings required for them, is many times offset by the reduction of heat losses over low settings.

At the South Boston station of the Boston Elevated Rys. Co., the B. & W. boilers are 8 ft. above the stoker grate at the rear. At the 201st St. station of the United Electric Light & Power Co., New York City, they are 10 ft. above; at the Northwestern station of the Chicago Commonwealth Edison Co. the front header is 13 ft. 3 in. from the floor; at the Delray station of the Detroit Edison Co. the gases travel 28 ft. from the underfeed stokers before they strike the heating surface; an 84-in. by 18-ft. horizontal tubular boiler at the plant of the North Newark Cold Storage Co., Newark, N. J., is 72 in. above the grate. High settings are as advantageous in small as in large plants.

The ideal condition, and one that can be closely approached, is to have the setting high enough so that no visible flame will be noticed touching the heating surface, even under reasonably high ratings. The flame should consume itself before leaving the combustion chamber. At very high ratings and with long flaming coal, the flame reaches great heights. Here is an extreme example: With 275 per cent. rating and long-flaming West Virginia coal, the flame reaches the top of the combustion chamber in the Delray boilers at the Detroit Edison Co. This shows how much too low are 24-in. settings.

Combustion Rates

Next to heat losses by excess air because of leaky settings and improper firing, are those due to combustion rates far below the capacity of the boiler. Comparatively few plants are not subject to this usually inexcusable practice. Rated boiler capacity is partially disregarded in good operating practice, but while it is good as a guide in designing and buying, there is not much use for it in operating when care is used in forcing the boiler.

The boiler room represents a large part of the total power-plant investment. When boilers are run far below rating, the loss is double. Interest, insurance, depreciation, all large items in boiler practice, must be charged against all boilers in excess of those actually needed for the steam requirements, and also those needed for reserve or emergencies. In addition, the investment for those boilers not really required may be considered a nearly complete loss unless a corresponding increase in steam capacity will be needed soon after the initial installation. The other loss is a heat loss. As boilers are run below capacity, the excess air admitted increases rapidly, the CO_2 percentages drop likewise, and the fuel losses due to low CO_2 are too well known to be discussed.

Maximum boiler efficiency is nearly always obtained at a rating much below normal. The drop in efficiency is quite small for ratings as high as 200 to 300 per cent. Where peak loads must be handled, it might, and often would be, more economical to operate the boilers at 200 to 300 per cent. rating for a short time to carry the peaks, than to carry banked fires under standby boilers. This practice admits of greatly reducing the heavy overhead charges in the boiler room, which are such large factors in increasing the unit cost of power. The amount of overload must always be governed by the quality of the feedwater and the cleanliness of the heating surface.

The day is not distant when a far greater ratio of boiler capacity to that of the prime movers will prevail in manufacturing plants, especially those subjected to peak loads. This practice is being vigorously followed out in large central stations and railway power houses. As much as 4.7 kw. is being allowed per rated boiler horsepower.

Owing to future growth or other local conditions, overhead charges on the boilers installed to care for the future demands are unavoidable. The overall expense is needlessly increased when all the boilers are run considerably below rated capacities, as is common practice. Wherever possible, building and equipment foundations should be put in, and as the demand compels, the building and equipment are extended accordingly. This is done in the best central-station practice, and there is no real reason why it will not apply in most rapidly growing manufacturing plants.

Troubles Due to High Ratings

Deterioration of furnace walls and stokers is considerably greater at high than at low ratings. In some plants the question of how much firebrick per unit of delivered steam one can afford to burn, determines the boiler ratings.

Firebrick Troubles

The brick walls in modern boilers do not support more than their own weight, and this makes possible much higher combustion rates than if these walls were loaded. The melting and fusing temperatures of firebrick, or the temperatures at which it becomes soft under its own load, are of great importance. Inseparable from this is the quality of mason work in the walls, and the lineal expansion of the brick under furnace temperatures. Brick that expands too much will surely cause the walls to bulge. The inspection of the setting must be as thorough as that of the heating and steam surfaces when high rating obtains.

The fusing temperature of the brick may be influenced by the slagging quality of the ash. The firebrick may fuse at, say, 3000 deg. F., the ash slag at 2600 deg., but in combination in a furnace both may slag at, say, 2400 deg. When the furnace temperature is below the fusing temperature of the brick and the brick and the ash fuse considerably, it will pay to get a coal having a different proportion of constituents to prevent excessive slagging of the firebrick.

Tube Troubles

Many operating engineers fear that at very high combustion rates, the steam bubbles are formed so rapidly that they do not allow the water to make good contact with the tubes, and consequently there is grave danger of overheating. Experience shows that with clean tubes and good circulation, the water will absorb the heat as rapidly as it is practicable to supply it. The danger lies in scaled or scaled and muddy tubes. At high rating, therefore, great care must be taken to precipitate the suspended matter and neutralize the scale-forming solids, especially those that form sulphate scale. The nature of the feed water may make it hazardous without being thoroughly treated to run at extremely high ratings. The Passaic and the Delaware Rivers (New Jersey) are examples of such waters. Before boilers heretofore run at or below normal rate are to be run at very high rates, it should be positively known that the tubes are clean to the metal. It is not uncommon to find boilers having scaled tubes which were thought to be free of scale.

If soda-ash is used and there is to be a change from low to high ratings, the amount of soda-ash should be reduced until it is known what quantities may be supplied without causing severe foaming and priming.

Corrosion

The most widely accepted theory of corrosion is the electrolytic. Briefly, it is this: The substances composing the metal are not intimately and thoroughly mixed and distributed. Electrically, some substances are negative and others are positive. The water or dampness covering the metal acts as an electrolyte to set up a flow of current between one positive substance and one negative. The metal goes into solution at the point from which the current flows and pitting begins. Experience shows that pitting is often started at places on the plate where pieces of scale or other foreign substances have been deposited.

Boilers left full of water while out of service often suffer from external corrosion, because the cool heating surface condenses the vapor in the air, the vapor covering the surface, which soon corrodes. Corrosion from wet soot has been mentioned.

Where creek and river waters are used, and especially if the streams drain coal, iron or other mining districts, the corrosion will usually be severe. During the spring, when the snow melts, much acid is carried by the waters that drain mining districts and often the water must receive special treatment. "Home" remedies are not to be recommended for such conditions. Be sure to closely inspect for corrosion where tubes enter the heads or headers. I have seen tubes eaten away to $\frac{1}{32}$ in. thick at these points. After cleaning the tubes, examine them by the aid of a portable electric lamp pulled through from one or both ends. Never allow men to work in a boiler which is being filled with steam through a leaky stop valve without having one man to watch and play a hose into the boiler. It is difficult to pull an unconscious man through a manhole.

Other Considerations

If a plant designed for saturated steam is to use superheated steam, stop valves and gaskets should be adapted to the new conditions at the time the superheaters are installed. Failure to do this has turned 75 per cent. of the operating engineers against superheated steam.

Where coal costs more than $3 per ton and the plant's capacity is reasonably high, the value of economizers is unquestioned. Small plants will not find them advantageous unless the exit gases are of a very high temperature or the water is used for industrial purposes.

Automatic stop valves should be considered as necessary as safety valves. In preventing a shutdown of all boilers in case of accident to one, these valves would save far more than their cost.

The Purchase of Coal

The cost of coal in any kind of plant will be between 55 and 75 per cent. of the total power cost. An average in well conducted plants, favorably located, will be 65 per cent. The chief reason for scientific methods of purchasing are, therefore, sound, even though the power cost in manufactories is only 2 to 7 per cent. of the total cost.

An example worthy of mention to show the effect of the increasing price of fine grades (Nos. 2 and 3 buckwheat) of hard coal, and as evidence of the necessity of careful buying, is that presented by practice in a large Eastern textile manufactory. About 18 years ago this firm saved approximately $50,000 a year on about 45,000 tons by using these instead of the large grades. Today, with the most careful buying and burning, $600 a year is the best saving possible on the same consumption. The first year New York City bought coal under specification, a total saving of over $200,000 was realized. New York State will hereafter purchase coal under specification, and by prudent buying and slight corrections in the boiler-room practice of its 42 institutions, expects to save at least $250,000 a year.

No explanation is necessary to convince one of the value of buying coal on specification, but much needs to be said of the character of the specifications.

The purchase of coal on a strict British thermal unit basis is wrong to the dealer and the user. The heat value in British thermal units may be high, but the fuel may be so unsuited to the furnace and grate that it would be prohibitive. Further, the probability that the samples on a large shipment reduced finally before analysis to about a thimbleful, are not truly representative, is too great to be a deciding factor. The power plant is not a laboratory, and practical methods are necessary in all its departments.

If the coal is bought strictly on analysis, the percentage of ash, volatile combustible, sulphur and the limits in heat units should be specified for each kind and grade of coal. Whether or not the allowable moisture content should be specified is a question on which authorities are somewhat divided. I understand that the Bureau of Mines recommends disregarding it, partly; it is not mentioned in the New York State specifications, the reason being that neither the miner nor the dealer can well control it, and as the coal is weighed at the point of delivery and the payment is based on that weight, the purchaser may gain by the drying of the coal in transit, or the dealer may gain by rains or leakage in boats while the coal is in transit. Personally, I believe a limit for moisture should be set when the weight of the coal "as delivered" is paid for. Large shipments of fine coal can hold a large amount of water. Also there is too much temptation to "saturate" it before weighing. Comparatively useless water should not be bought on a coal-price basis.

Whether a bonus should be paid on coal of a quality better than specified, is a much discussed question. The experiences of many large consumers who buy on an evaporative basis show that on thousands of tons delivered but little coal is of better quality than specified. It runs below usually, but not so much as to warrant penalizing the dealer, except at rare intervals. A new dealer, unfamiliar with the methods of the consumer, will frequently try to "get by" with a shipment inferior to the trial sample, but when he learns that the quality is being checked with that specified, and that he must either suffer a reduction in price commensurate with the inferior quality or take away the shipment at his own expense, he is careful to meet the specifications at all times. It pays, therefore, to purchase from a contractor who has learned his lesson.

Coal should be purchased on a basis fixed by the value of the fuel to the plant and not on its British thermal unit or ash content. Coals giving good evaporation results may so clinker and slag as to be intolerably troublesome to burn. When coal is bought on an evaporative basis, therefore, the contract should contain a clinker and slag clause, besides those relating to slate and bone; otherwise a prolonged dispute will arise. It may or may not be possible to get a reduction in price, for the contractor has the advantage of having met specifications as to evaporation results. The contractor should, of course, have the privilege of conducting a test when disputes arise. The boiler on which a test is run should have the blowoff blanked and the feed water carefully measured in a calibrated tank or meter. The temperature must also be recorded at the tank or meter and at the entrance to the boiler, if economizers are used.

That the use of soft coal must continue to increase each year will readily be realized by a casual inspection of a map of the coal fields of this country, for a comparatively small spot indicates the anthracite fields. The supply being limited, the price keeps advancing which promotes the sale of soft coal.

Large manufacturers, especially those in manufacturing centers like Newark, N. J., might find it quite advantageous to buy their coal by specification through a joint committee. A testing bureau to check the quality of shipments by analysis could be maintained. Most plants could use the same grades of coals by slight changes in grates and boiler-room methods. The first year's saving would exceed the initial cost of the plan.

Computing Thermometer Stem Corrections

By Charles M. Reid

SYNOPSIS—With the aid of alignment charts thermometer-stem corrections may be obtained readily for both simple emergence and for calorimetric work where the difference in temperature is desired.

During September, 1910, there appeared in Power a family of hyperbolas plotted to facilitate the calculation of the correction for the emergent stems of thermometers. The writer has applied the principles of the alignment chart to these calculations, and believes that this method will prove more convenient for use in everyday work.

For the benefit of those who may not be familiar with the stem correction, the following explanation and derivation of formulas is given:

Imagine a thermometer entirely submerged in some medium at a temperature T. Then, as thermometers are generally graduated for total submergence, the observed temperature t will be the same as that of the surrounding medium, or $t = T$.

Now suppose that the thermometer is submerged only to some division N with a part of the mercury column $t - N$ exposed to a cooler medium. The mercury, contracting because of the difference of temperature between the bulb and the stem, or $T - f$, will give a lower reading t than the true temperature T. However, the glass in the stem also contracts, making the bore smaller, thus increasing the observed temperature t. The contraction in length of the stem will also apparently increase the height of the mercury.

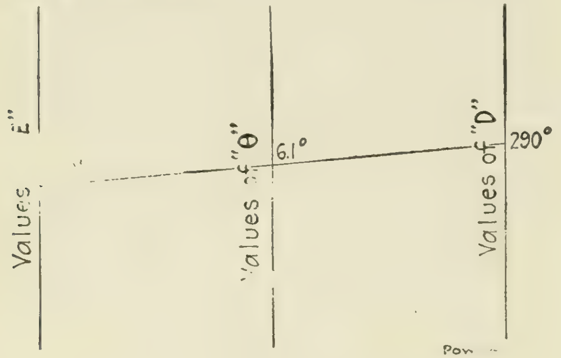

Fig. 1.

Now, let E_M represent the coefficient of cubical expansion of the mercury for some range of temperature, and E_G the coefficient for glass through the same range. Let $K = E_M - E_G$. Then the correction θ in degrees to be added to the observed temperature t will be

$$\theta = K\ (t - N)\ (t - f)$$

The correction θ is to be added if the stem is at a lower temperature than the bulb, and subtracted if the stem is at a higher temperature than the bulb.

Scheel* has given, for the volume of mercury at a temperature t degrees Centigrade, the formula

$$V_t = V_o\ (1 + 0.00018182t + 0.0000000078t^2)$$

which, when reduced to Fahrenheit units, becomes

$$V_t = V_{32}\,[1 + 0.00010101\ (t - 32) + 0.0000000013\ (t - 32)^2]$$

Applying these formulas, the average coefficient of cubical expansion of mercury is found to be 0.0001826 per deg. C., and 0.00010144 per deg. F. These coefficients apply for a range of 1000 deg. in each case.

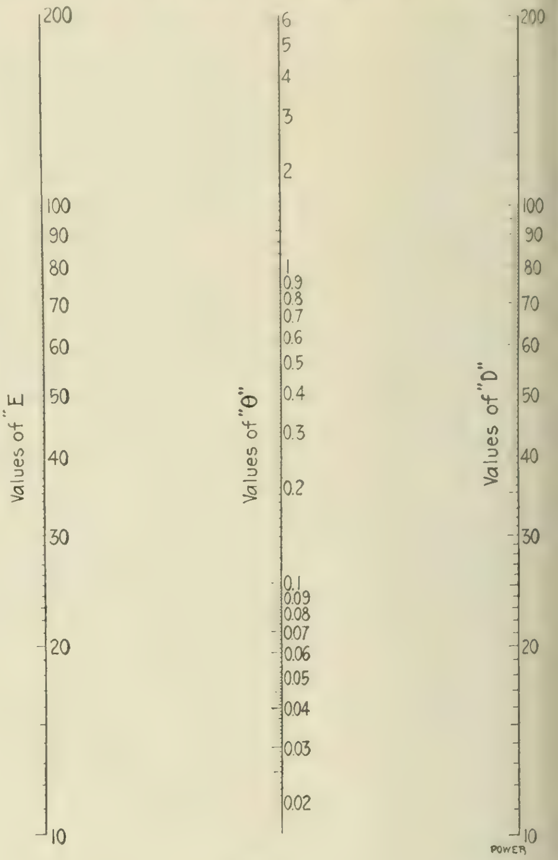

Fig. 2.

Reichsanstalt† gives the coefficient of cubical expansion of Jena glass as 0.00002533 per deg. C., which reduces to 0.00001407 per deg. F.

Then, for a Centigrade thermometer,

$$K = 0.0001826 - 0.00002533 = 0.00015727$$

say, 0.000157, and for a Fahrenheit thermometer

$$K = 0.00010144 - 0.00001407 = 0.00008737$$

say, 0.0000874.

Substituting these values of K in the fundamental equation,

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*Fifth revised edition, Smithsonian Physical Tables, p. 225.

†Fifth revised edition, Smithsonian Physical Tables, p. 224.

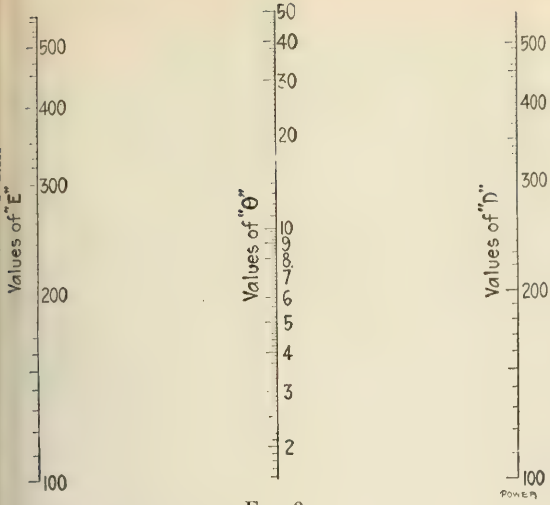


FIG. 3.

$\theta = 0.000157\ (t - N)\ (t - f)$ for a Centigrade thermometer

and

$\theta = 0.0000874\ (t - N)\ (t - f)$ for a Fahrenheit thermometer

For convenience, E may be used in place of $(t - N)$, and D in place of $(t - f)$.

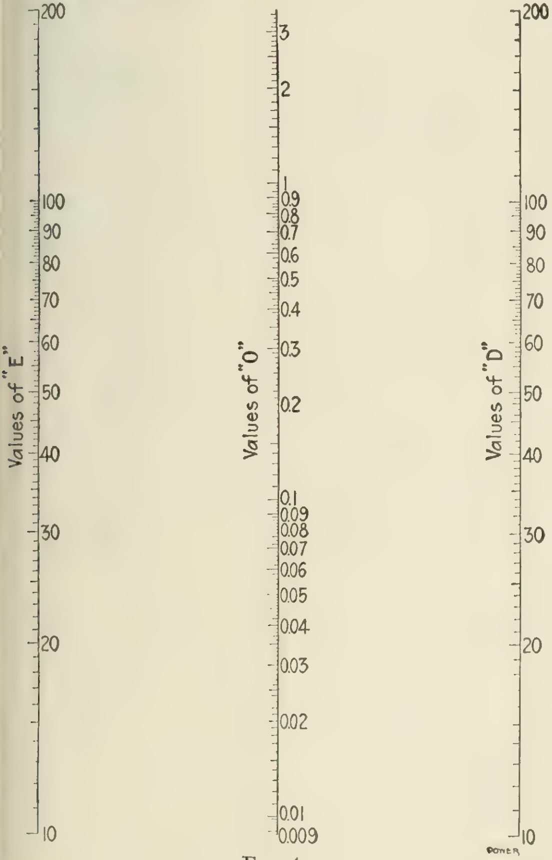


FIG. 4.

Now consider another case, that of calorimetric work, where the absolute reading of temperature is not desired so much as the difference between the initial and final temperatures in the calorimeter. Then comes the question: "What correction, if any, is required for the emergent stem in this case?"

This is just as simple as the preceding cases. For example, let the initial temperature be t_1 deg., final temperature t_2 deg., temperature of stem f deg. and thermometer submerged N degrees. What is the correction to be added to the differential temperature $t_2 - t_1$?

From the foregoing paragraphs it will be seen that at a tempearture t_2, the correction is

$$\theta_2 = K\ (t_2 - N)\ (t_2 - f)$$

while at t_1 it is

$$\theta_1 = K\ (t_1 - N)\ (t_1 - f)$$

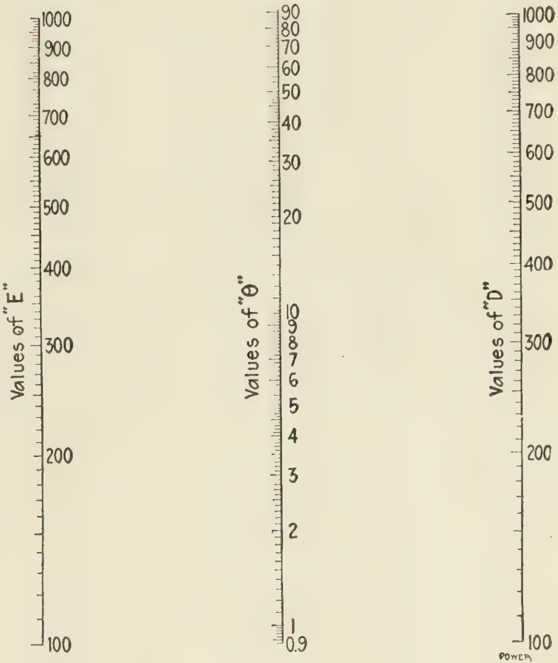


FIG. 5.

Clearly, the correction for the difference $t_2 - t_1$ will be $\theta_2 - \theta_1$. But

$$\theta_2 - \theta_1 = \theta = K\ [\ (t_2 - N)\ (t_2 - f) - (t_1 - N)\ (t_1 - f)\ ]$$

Simplifying the above

$$\theta = K\ (t_2 - t_1)\ (t_1 + t_2 - N - f)$$

where K is 0.000157 or 0.0000874 for Centigrade or Fahrenheit thermometers, respectively.

For convenience this equation may be written

$$\theta = KdX$$

in which θ and K are as before,

$$d = t_2 - t_1$$

and

$$X = t_1 + t_2 - N - f$$

Fig. 1 illustrates the method of making the calculations; for example: Let $t = 390$ deg.; $f = 100$ deg. and $N = 150$ deg., then

$$E = t - N = 240\ deg.$$
$$D = t - f = 290\ deg.$$

and $$\theta = 6.1 \; deg.$$
for a Fahrenheit thermometer.

Figs. 2 and 3 are for Centigrade thermometers, the upper limit being chosen 560 deg., or approximately 1000 deg. F.

Figs. 4 and 5 are similar to Figs. 2 and 3, but are for Fahrenheit thermometers.

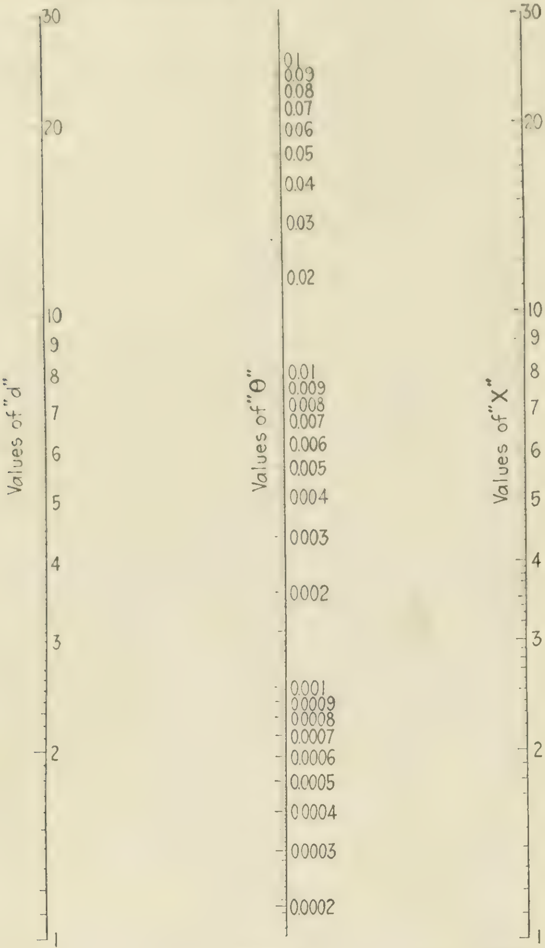


FIG. 6.

Fig. 6 is intended for use in making corrections for differential readings of temperatures. As most thermometers intended for calorimetric work are graduated in Centigrade degrees, Fig. 6 is for Centigrade thermometers, and no chart has been made for Fahrenheit thermometers.

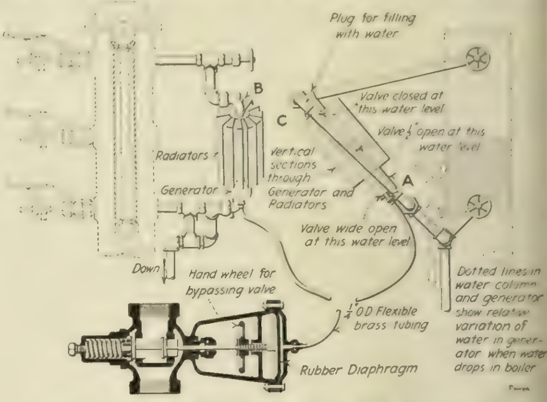
Hydro-electric Fertilizer Plant—American capitalists have purchased extensive water-power privileges extending along the Saguenay River from Lake St. John to tidewater in the Province of Quebec. It is said that some 300,000 hp. is to be developed at an estimated cost, for development of hydro-electric power and construction of plant, amounting to \$60 or \$70 per horsepower, to be used for the production of phosphoric-acid fertilizer in electric furnaces by heating phosphate rock (Florida pebble) with silica or sand. It is claimed that approximately 3 tons of 45 per cent. double superphosphate can be produced per horsepower per annum in the proposed plant.

S-C Vertical Feed-Water Regulator

This feed-water regulator is designed to be attached to the water column of high-pressure boilers, to control the height of the water within certain limits and at the same time to give a continuous graduated feed.

The apparatus consists of a balanced valve made for pressures up to 350 lb., having an inserted Monel metal or nickel seat. This valve is operated by a rubber diaphragm, which works against a spring at the bottom of the valve disk, with cold-water pressure on the top of the diaphragm. The valve thus controls the discharge of feed water to the boiler.

The other essential features are the generator *A* and radiator *B*. The generator consists of a cylinder through which a $\frac{1}{8}$-in. pipe-size tube *C* extends. The tube is connected to the water column or to the boiler by extra-heavy $\frac{3}{8}$-in. nipples and fitting, so arranged that its position and location may be varied to meet the operating conditions. The tube is under boiler pressure, the lower part being filled with water to the corresponding level in the boiler. The space above the water is filled with steam through the top connection for the water column or boiler.


Plug for filling with water
B
C
Valve closed at this water level
Valve $\frac{1}{2}$ open at this water level
Radiators
Vertical sections through Generator and Radiators
A
Generator
Valve wide open at this water level
Down
Hand wheel for bypassing valve
$\frac{1}{4}$ OD Flexible brass tubing
Dotted lines in water column and generator show relative variation of water in generator when water drops in boiler
Rubber Diaphragm

DETAILS OF VERTICAL FEED-WATER REGULATOR

In the generator the space surrounding the tube is connected to the valve diaphragm by flexible, seamless brass tubing and is filled with water as shown. The water within the tube is exposed to radiation through the radiator *B*, and exposed to the heat of the steam in the tube. Any portion containing steam will be heated and will evaporate the water in the generator surrounding it into steam. The steam, being confined, drives the water through the connecting tube to the diaphragm, opening the valve in proportion to the amount of tube exposed to the steam.

Heat radiated through the thin walls of the generator assisted by the attached radiators, condenses the steam in the generator and reduces the pressure therein as rapidly as the tube fills with water. The spring on the reverse side of the valve moves the valve disk toward the closed position.

If the generator is placed vertically, the water in the boiler must drop 10 in. to fully open the $2\frac{1}{2}$-in. valve, while if the generator is placed nearer a horizontal position, the valve will be fully opened in relatively closer levels. Under ordinary conditions, a 30- to 45-deg. angle is desirable, as this position will carry a higher water level with light loads and will thus help on a peak load.

The regulator, manufactured by the S-C Regulator Co., Fostoria, Ohio, is said to give a constant feed and water level. As will be noted, the regulator is free from floats, pilot valves, weights and levers and its one moving part is the valve stem.

If the feed-water temperature is above 212 deg. F., or if the water is bad, an outside spring is used. An extension stem is secured to the valve disks, and by using a monkey wrench on the end unit the disks can be rotated against the seat, crushing any scale that may accumulate and cleaning the valve while it is in service.

Power-Limiting Reactances

By John A. Randolph

SYNOPSIS—Reactances as used to protect generating apparatus from heavy surges due to short-circuits. The operation, connections and construction of the principal types of such reactances are explained.

* * *

The reactance coil in its various forms is extensively used on light and power systems to provide the impedance or choking effect necessary under certain conditions in which alternating or oscillatory currents are involved. It is commonly used on direct-current overhead lines in connection with lightning arresters and in this service is generally known as a choke coil. However, its most extensive and varied application is on alternating-current systems.

The principal uses can be classed under three headings: First, those employed in connection with lightning arresters and other protective apparatus; second, those used for voltage regulation in connection with compound-wound rotary converters, for giving stability to the operation of synchronous motors and to assist in tying stations together over lines of high resistance; third, those used with generators, feeders, busbar sections and auxiliary apparatus to limit the current which can be discharged into a short-circuit. This article will be devoted chiefly to the last class.

Operation

The reactance coil accomplishes its purpose by reason of the back pressure which it exerts against alternating currents. This back pressure is known as inductance or the electromotive force of self-induction.* Its value depends upon the frequency of current reversals and the strength of the magnetic field. The latter depends upon the number of turns in the coil and the strength of current; in other words, the ampere-turns of the coil. The value of the electromotive force of self-induction is expressed by the equation

$$E_s = 2\pi f L C$$

in which f is the frequency, L the coefficient of self-induction and C the current in amperes. From this it will be seen that the intensity of the electromotive force of self-induction in a given coil is dependent upon the strength and the frequency of the current. Hence the greater the current or frequency, or both, the greater will be the electromotive force of self-induction.

It is due to this action that reactance coils are able to keep out lightning discharges from the apparatus which they protect. The lightning is of a highly oscillatory nature and produces a counter electromotive force in the reactance coil so great that the discharge is forced through the lightning-arrester gaps to ground, the arrester gaps offering less opposition to the current than the impedance of the coil.

The effectiveness of the reactor in protecting apparatus against injury from short-circuits depends upon the fact that, as the resulting current assumes an abnormal value, the inductance of the coil also rises until it becomes so great as to keep the current from rising high enough to injure the apparatus. Reactors are so designed that, with the normal current flowing, the counter electromotive force is such a small percentage of the working voltage that only a comparatively small impedance is offered. However, with abnormal currents, the inductive effect assumes a value which enables it to greatly impede the current and thus to prevent it reaching a value high enough to cause serious injury. The short-circuit current of a generator not protected by a reactor may rise to 20 or 30 times the normal full-load current, depending upon the amount of impedance contained in the arma-

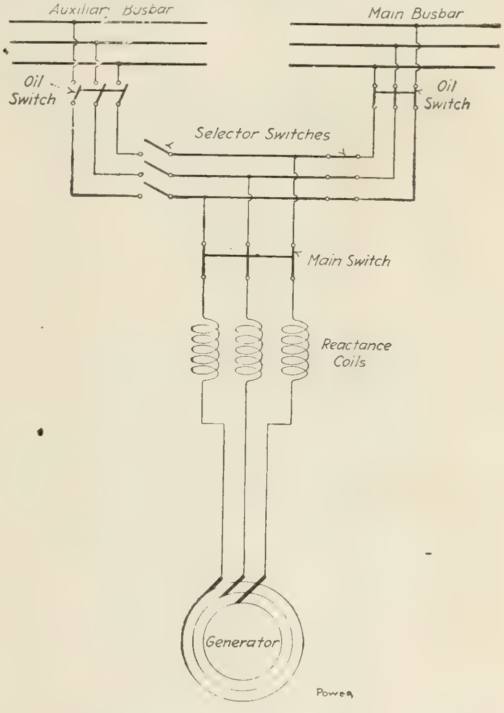


Fig. 1. Showing Reactances between Generator and Busbars

ture of the generator. With a properly chosen reactor connected to the generator, the short-circuit current will be reduced to less than half this amount.

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*See "Power," Feb. 24, 1914.

The effectiveness of the reactor as a protection against surges may also be explained in the same manner as in the case of short-circuits; the heavy currents resulting from a surge increase the impedance to such an extent that damage is prevented.

Uses

With the increasing capacity for which modern large generating stations are designed, the disastrous results of short-circuits have become more pronounced. With stations having a normal output of many thousands of kilowatts, the possible momentary discharge into a short-circuit, unless effectively checked, is almost unlimited. The automatic oil switches will open the defective circuit and stop the current flow if it is not too great. However, if the short-circuit be at or near the station, the current may assume such a value that opening of the oil switch will occasion a heavy surge and produce a high momentary rise in voltage. This may cause the current to jump to ground either at the switch or at some other point on the connected circuits. The arcing, upon the opening of the switch, may also be so intense as to seriously damage or ruin it. Moreover, the opening of oil switches requires a certain interval of time which, although short, may be sufficient to permit serious damage to generators and other apparatus. It is to avoid so far as possible such contingencies that the use of reactances at generating stations is now becoming the general practice.

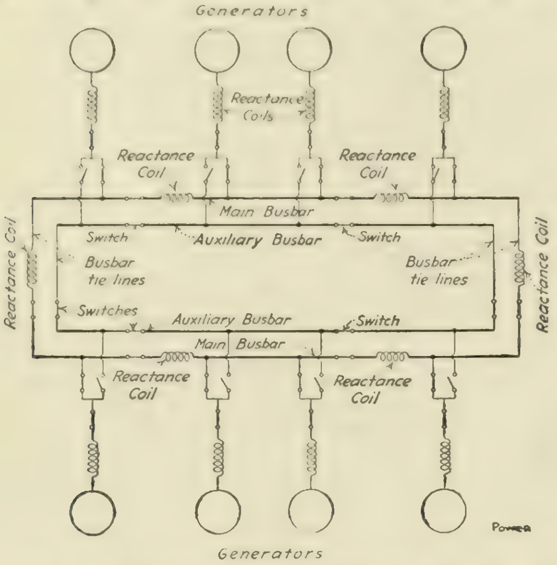

FIG. 2. REACTANCES BETWEEN BUSBAR SECTIONS AS WELL AS BETWEEN GENERATOR AND BUSBARS

Reactance in the various circuits may be provided in one of two ways or by both. It may be supplied by making the design of generators and transformers such that they will contain an amount of reactance sufficient for protection against short-circuits. This procedure may be commendable and give good results under certain conditions. However, it has been found, especially with large apparatus, that a reactance of more than 2 or 3 per cent. affects the regulation of transformers and by modifying the construction of the generator coils lowers the efficiency. Therefore, it is advisable to provide the extra reactance in the form of exterior coils. The amount of reactance of these coils is usually expressed as a percentage which represents the ratio between the reactive pressure at full-load current, and the voltage of the circuit.

CONNECTIONS

The connections of reactances to their respective circuits are comparatively simple, as they are always placed in series with the lines which they are designed to protect. Generator reactances should be connected between the generator and the busbars and on the generator side of the oil switch, as shown in Fig. 1. It will be observed that in case of a short-circuit on the busbars, feeder circuits, or any of the other machines, the generator will be protected by the choking effect of its reactor. On the other hand, if a short-circuit occurs in the alternator itself, the busbars will be prevented from discharging a heavy current into the fault, and thus wrecking the generator.

In Fig. 2 is shown the diagram of connections used between busbar sections and in busbar tie lines. In case of a short-circuit on any section, the adjoining sections are prevented from discharging their full capacity into the fault. Thus, not only is the apparatus protected, but a possible general shutdown is avoided.

CONSTRUCTION

Reactance coils, while of comparatively simple construction, require careful consideration in design. In turbo-generators of large capacity the cross-section of copper required is so large that it is often impracticable to provide the necessary sectional area in a single conductor, owing to the difficulty of winding and also because of eddy-current and ventilating obstacles. These difficulties are avoided by providing two cables connected in parallel and placed side by side. The cables are stranded to reduce eddy currents and to render flexibility in winding. Bare or thinly wrapped cable is generally used to facilitate free ventilation, to make the overall size of the coil smaller than it would otherwise be, and to render the first cost as low as is consistent with good design.

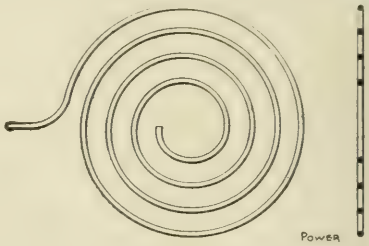

FIG. 3. GENERAL FORM OF PANCAKE TYPE OF REACTOR

In insulating the coil it should be remembered that the reactor may at any time be subjected to voltages far in excess of normal. The insulation must, therefore, be sufficient to withstand these strains. Moreover, in any coil through which a current is passing a certain amount of heat is generated which causes a rise in the temperature dependent upon the proximity of the component turns, upon the strength of current and upon the ventilation. This is especially important in the design of large reactors. The conductor must, therefore, be so wound and supported that a free circulation of air can take place at all times. To provide an insulation both electrically and mechanically secure and which will not be injured or affected by heat, porcelain, composition and treated wood are used, supplemented by asbestos or mica. The parts used for insulation must also serve as supports for the cables and must be sufficiently strong to withstand the mechanical stresses.

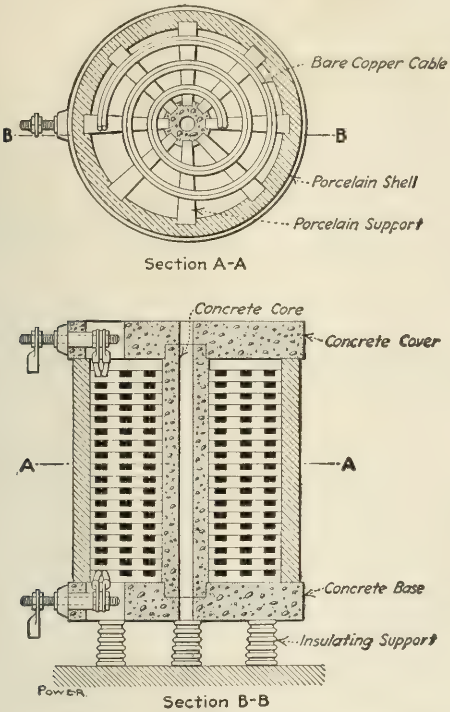

Fig. 4. Section and Plan of Pancake Type of Reactor

Another important feature is the heavy magnetic field induced in the coil and especially at a time of short-circuit. Iron cannot be used as a core for the reactor as it would become magnetically saturated in times of trouble and thus impair the efficiency. This is on account of the excessive size and weight that would be necessary. Furthermore, no magnetic material of any kind should be used in the construction of the coil and no metals of this nature should exist in close proximity to the reactor. For this reason brass is commonly used for tie-bolts, screws, fittings and connections.

Types

In the construction of reactors two general forms are followed, the pancake and the drum types. By the pancake type is meant a coil whose layers are wound in planes perpendicular to the axis of the coil, as in Fig. 3. In the drum type the layers are of cylindrical form and are wound concentrically with the axis. An advantage claimed for the pancake type is that no two points of the reactor winding having a wide difference of potential are adjacent. This renders insulation easier and gives the coil a large factor of safety against mechanical and electrical stresses.

Fig. 4 is a form of construction used with reactors whose layers are of the pancake type. The cables are placed in slots in a series of porcelain arms arranged radially to the axis of the coil and held in place by the concrete core at one end and the outer shell at the other. The arms of the different layers are placed directly over those of the layers underneath in such a manner that they rest upon the latter, thus rendering the coil compact and mechanically secure against heavy stresses between layers. The outer porcelain shell serves both to insulate the coil from surrounding objects and to assist in the support of the interior parts as well. It is made up of segments, thus making it easy to assemble or take apart. The ends are of concrete and are perforated with radial slots to allow a circulation of air. The various parts are held together by brass tie-bolts fastened at the ends to the top and bottom covers and extending through the outer shell. The cores are of concrete or alberene stone and are so constructed as to hold the radial supporting arms securely in place, at the same time allowing for up or down movement.

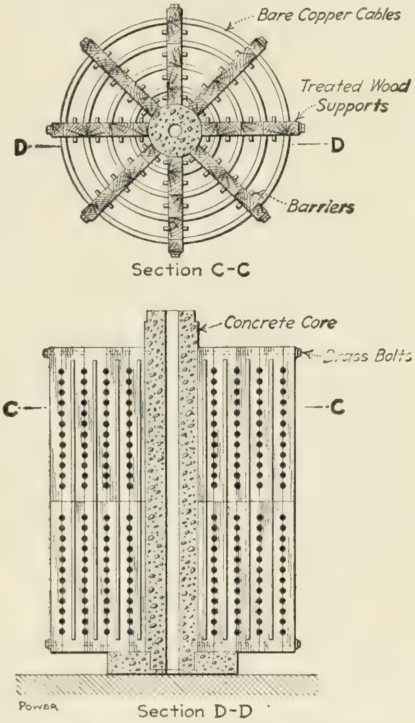

Fig. 5. Drum Type of Reactor

Another type of reactance which is widely used employs the drum type of windings, as in Fig. 5. The cables are held upon strong supports equally spaced radially to the axis and extending throughout the full length of the reactor. The supports are commonly made of treated wood. As a protection against heat and also as an added insulation, an asbestos covering is placed between the cable and the wood. Wood barriers are fastened to the supports to afford a greater area of insulating surface between the respective layers. The supports are held in place by brass bolts fastened to nonmagnetic anchor plates in the core. The core is of concrete and has a longitudinal hole extending through the center as a convenient accessory for assembling or taking apart and also as an added feature of strength. It is a common practice in drum-type reactors to divide the winding into two sections so wound that the reactance terminals can be located on the outside of the coil without the necessity for a crossing or unsymmetrical arrangement of cables.

PERFORMANCE

Reactors under test have been found to reduce the short-circuit current on large generators to a value less than half what it would otherwise assume. Moreover, it has been found that when generators equipped with reactors were subjected to a full short-circuit, no damage has been sustained by the generator and its apparatus, although various voltages and conditions were used in the tests.

Reactors are now commonly used on generators, busbars, exciters, motor generators, transformers and to some extent on feeders. The percentage of reactance generally employed in the coils varies according to conditions. For exciters and motor generators it is usually low, being commonly between 3 and 4 per cent. For generators it usually ranges from 4 to 8 per cent., depending upon the output. Reactors placed between busbar sections and in busbar tie lines, owing to the large amounts of power involved, generally contain a comparatively high reactance the value of which is commonly about 18 or 20 per cent.

When once installed, reactors require but little attention, this consisting chiefly of an occasional inspection and removal of accumulations of dust.

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Moisture in Compressed Air

By Frank Richards

SYNOPSIS—Free air always contains moisture, and practically nothing can be done for its removal until the air has been compressed, when troublesome moisture can be removed by draining it off as water; the higher the pressure the greater the opportunity.

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It is to be noticed that correspondents of POWER are still inquiring about the way to keep the water out of compressed air and to prevent the freezing up of the exhaust passages of air-operated machines. This water and freezing-up trouble began with the earliest using of compressed air, and always must be encountered if the proper arrangements are not made to avoid it. Those of long experience with compressed air have generally learned, more or less completely, what it is necessary to do in the case, but as a second or a third generation of air users is now getting into the business, it seems to be necessary to rehearse the matter again, with occasional repetitions in the future.

THERE IS NO DRY FREE AIR

In the first place, practically nothing can be done until the air has been compressed. Carrying water is one of the principal functions of the air, and we never catch it that it does not carry more or less water vapor, mixed with it. The daily reports of the weather show that humidity is the most variable of the atmospheric conditions, being much more so than the temperature or the barometric pressure. But there is a lower limit of atmospheric humidity, far above the zero mark, which is never reached and seldom closely approached. When the humidity reaches 100 per cent. that becomes the "dew point," for the conditions then prevailing; the air can carry no more moisture in the form of vapor, the excess being immediately condensed into water, at first only minute globules, but still actual water.

Until the dew point is reached the air is perfectly transparent, and to the touch it is dry air; but when in the upward direction the dew point is passed, the condensed vapor is seen as mist, fog or cloud in the air, more or less dense, according to the amount of water liberated, and the air in this condition will wet, or at least dampen, whatever it may happen to touch.

The reason that the atmospheric humidity reports are so constantly varying is that the moisture-carrying capacity of the air is so dependent upon two constantly varying conditions: pressure and temperature, the latter especially. So far as the pressure alone is concerned, the vapor-carrying capacity of the air is almost directly as the volume, or inversely as the absolute pressure. Thus, if air is taken into a compressor at atmospheric pressure, say 15 lb. absolute, and at 50 per cent. humidity (though it is apt to be above that) then if the air is compressed to 15 lb. gage, or two atmospheres, its humidity becomes 100 per cent., and the air can carry no more water as vapor. If the same air is compressed to 45 lb. gage, 60 lb. absolute, or four atmospheres, then one-half of the vapor is condensed into water, and so on for other pressures. If the air we started with at 50 per cent. humidity was compressed to 105 lb. gage, 120 lb. absolute, or eight atmospheres, then only one-quarter of the original moisture could remain in the air as vapor, and three-quarters of it would be condensed into water. These figures will be referred to later.

We have gone along here, as theorizers are apt to do, considering only the one condition of pressure, or corresponding volume, and entirely ignoring the temperature. We could, of course, only have realized the results above predicted if the temperature had remained constant all through, which certainly would not have been the case.

If, now, we consider the temperature alone of the air under compression, we come to results quite different, and, we may say, quite astonishing. The capacity of air for vapor of water rises rapidly with increase of temperature. The following gives approximately the weight (lb.) of aqueous vapor per pound of atmospheric air at 50 per cent. of saturation and at various temperatures:

Temp. Fahr.	Weight of Vapor per Lb. of Air	Temp. Fahr.	Weight of Vapor per Lb. of Air
60	0.00547	140	0.07575
80	0.01099	160	0.14776
100	0.02127	180	0.32471
120	0.04020	200	1.13400

From these figures it will be seen that it requires a rise of only a little over 20 deg. F. to double the vapor-carrying capacity of air. From 60 deg. to 200 there would be seven of these doublings, or the vapor-carrying capacity of the air would have increased from 1 to 128. The actual increase shown is 1.1340 ÷ 0.00547 = 206, but this excess is accounted for by the much more rapid rise in the last interval between 180 and 200 deg.

It is to be remembered that the above figures apply to given weights, or actual quantities of air, and not to volumes. In compressing to eight atmospheres the vapor-carrying capacity, so far as volume is concerned, is only one-eighth of what it was before the compression, but with seven doublings of vapor-carrying capacity in consequence of the rise in temperature, the air still has 128 ÷ 8 = 16 times the vapor-carrying capacity which it had before the compression began.

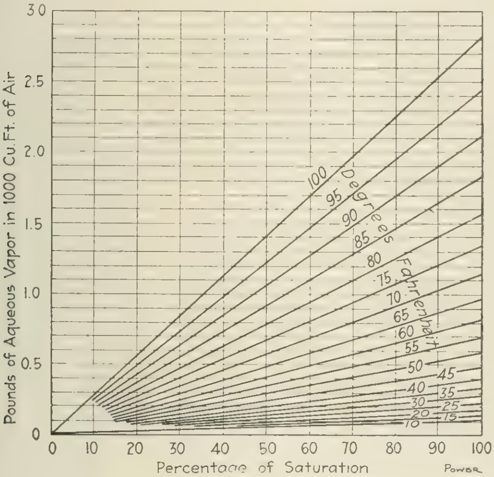


CHART SHOWING MOISTURE IN AIR

The case is more complicated than here outlined, because in adiabatic compression the volume during and at the completion of the compression is not reduced in proportion to the actual pressure increase; but, on the other hand, the temperatures are much higher than we have assumed, and it is evident that at the time of discharge the air must be really in a thirsty condition, although there has been no diminution of its vapor content.

In connection with the preceding, the diagram shown, will be found serviceable. It shows the weights of aqueous vapor in pounds per 1000 cu.ft. of air for practically the entire ordinary range of atmospheric temperatures and for different percentages of saturation, the latter being read horizontally at the bottom and the weights of water vertically at the side of the diagram. Each oblique line, or "curve," is figured for the temperature which it represents. The greater spacing for the higher temperatures, showing the increased water capacity, is quite striking. At 100 per cent. saturation, as also for any other percentage, the difference in the moisture content between 100 and 95 deg. F. is just equal to the difference between 45 and 10 deg., the latter difference being seven times as many degrees as the former. By extending the scale of temperatures upward, the differences would, of course, show much larger.

When free air is taken into a compressor at a normal temperature of, say, 60 deg., and is compressed to 105 lb. gage, the theoretical temperature is close to 500 deg., which temperature is much lowered if the compression be in two stages with efficient intercooling. If there is no aftercooler, it is doing well if the air is delivered at a temperature not above 200 deg.

The air now is in no condition to give up any of its moisture, and with the air receiver located near the compressor, the air is only slightly cooled, if at all, in passing through the receiver. There are those who continue to expect it, but they are continually disappointed.

THE COOLING OF THE AIR

If, however, the air after leaving the receiver is transmitted through suitable pipes to a considerable distance, as it usually is, it is almost certain to be cooled to about normal temperature. The specific heat of air is low, so that when its temperature is high to the senses or to the thermometer it represents little in actual heat units and has little heat to surrender to its surroundings, even when cooling rapidly. With the air thus cooled in the pipes, both the conditions of high pressure and of low temperature will be the best possible for the condensation and release of the greatest possible amount of water vapor. With the temperature of the air the same as it was before the compression began, the temperature will no longer have any effect in increasing the vapor-carrying capacity, and with the volume of the air reduced to one-eighth of what it was at the beginning, its vapor capacity will be only one-eighth of what it was. If the air when taken in is at the point of saturation, or 100 per cent. humidity, then if the air is compressed to one-eighth the volume, seven eighths of the vapor can no longer be carried as vapor. If the air was taken in at 50 per cent. of saturation, then only one-quarter of the original vapor can be carried as such, and three-quarters of the vapor will be condensed, and so on for other pressures.

DRAINING OFF CONDENSED VAPOR

When the saturation point is reached and passed, in consequence of a change in the combination of volume and temperature, the one being increased or the other reduced, then the air at once unerringly gives up all the surplus of vapor beyond what it can carry. That is, the vapor is condensed into liquid globules, but unless something more is done about it, the moisture will still remain in the air though in the liquid instead of the gaseous state. At the point of saturation, if the pressure were diminished or the temperature increased, some of the liquid would be vaporized again and become an intimate part of the air as before. If the conditions were reversed, the pressure being increased or the temperature reduced, more of the vapor would be condensed and the proportion of vapor remaining as part of the air would be reduced. On a summer day one may watch the clouds forming or gradually disappearing before his eyes as minute changes of pressure or of temperature occur.

The water condensed from vapor in the air, but still remaining in it in the liquefied condition, seems to be ready enough to get out of the air if given the opportunity. If compressed air just delivered from a compressor and thus overloaded with condensed moisture, could be kept in a mass in a quiescent state, the water would slowly go to the bottom of the containing vessel; but it has no time to stop when passing through an ordinary receiver. If the air is in motion the liberated moisture it contains will wet and cling to whatever the air touches.

If the air in this super-saturated condition, due to high pressure and low temperature, is passed through a steam separator, of any of the types of proved efficiency, the entrained water will be taken out of the air just as it is taken out of wet steam. As the wet air flows along in a pipe line, the inner surface of the pipe will be wet, the water will trickle down the sides and flow along in a stream at the bottom. If there are low places in the line, and if pockets or settling chambers are provided at these points, the water will accumulate there and can be drawn off at intervals. If the water is not thus drawn off, it must be carried along bodily by the air at last into the drills, pneumatic hammers or other tools, and the neglect to drain off the water before the air comes to the point where it is to be used is the cause of most of the trouble of which complaint is made.

It is a natural and proper inference from the preceding that the higher the transmission pressure of the air, the greater will be the opportunity of draining it of moisture, and if the opportunity is taken advantage of, the less will be the possibility of trouble in the subsequent use of the air. With a system calling for comparatively low-pressure air, with single-stage compression and without aftercooler or separator or any provision for taking the water out of the pipes, the water will not allow itself to be ignored when it comes to the exhaust passages.

REHEATING COMPRESSED AIR

Nothing probably needs to be said of the theoretical economy and advantage of reheating compressed air before putting it to use. By reheating, the working volume of the air may be quite materially increased at slight cost and the freezing-up trouble may be annihilated. It must be remembered, however, that practically little reheating has been or is being done. For driving tools or machines which are only operated intermittently, and which have no fixed position, reheating of the air is not practicable and costs more than it is worth, but for the driving of pumps or for any other constant employment, the air should always be reheated as closely as possible to the work.

How Englishmen Save the Auxiliary Exhaust

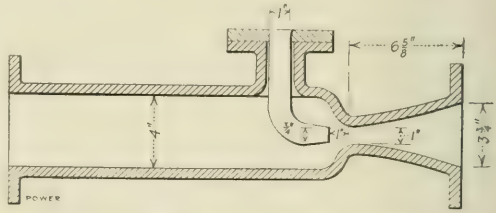
By E. R. Pearce

Since the turbine has been developed to its present reliable state, it is generally preferred to electric motors for auxiliary drive. It is much easier to keep up than some types of small engine, gives no more trouble than a motor to look after and, what is perhaps, most important, its reliability is greater.

Supposing turbines are adopted to drive the auxiliaries, and their exhaust naturally being free from all traces of oil, the point arises in the case of small stations as to the necessity of putting in a feed heater and storage, or carry the exhaust directly into the feed-pump suction line through the medium of either a suction condenser or exhaust-steam injector. Unless the lift is only 2 or 3 ft. a suction condenser should be used, the feed flowing to the point where the condenser is fitted if possible. In either case check valves must be fitted in the exhaust pipe to prevent water backing into the cylinder or turbine casing and also an atmospheric exhaust with suitable valves for changing over in case of necessity. Either of the above apparatus can be arranged in series or in single units, all exhaust being piped to them. Both devices are simple, require little attention and transfer all the heat in the exhaust steam to the feed water. To remove dirt and any scale-forming matter thrown down by the heating of the feed water, pressure-type filters may be used.

The only drawback to this arrangment arises in cases where a water gives off a large quantity of harmful gases, and these may be removed to a certain extent by fitting large air vessels with small automatic compressors and a bleeding arrangement fitted from either the top or bottom of the air vessel according to whether the gas given off is lighter or heavier than air. Most of this gas would be released by the churning action in the feed pump and if the air vessel be placed close over the pump undoubtedly a large amount would be trapped. In practice, however, it is doubtful if it would be worth fitting any such gas-removing scheme unless peculiar conditions existed to warrant it.

The following results are from an actual experiment, the accompanying sketch giving dimensions of the mixing chamber: The total suction head on the pump was 2 ft., the temperature of the exhaust steam 214.4 deg. F., the temperature of the inlet water 113.3 deg. F., the temperature of the discharge 129.5 deg. F., and the temperature of the outlet from the economizer 253 deg. F. The boiler pressure was 160 lb. gage. Under the above conditions the ¾-in. opening will pass 5.82 lb. of steam per minute. The weight of water 1 lb. of the exhaust steam would raise to the temperature of the discharge would be 62.8 lb., and the total weight passed per minute would be 371.316 lb., or 22,279 lb. per hr. In this particular case the coal burned per hour was 3136 lb., so that the evaporation was approximately 7 lb.



SKETCH OF EXHAUST-STEAM INJECTOR

Unfortunately the writer was unable to obtain the mean steam pressure in the pump cylinders, but the pump was a 9 and 5¼ by 10-in. duplex Worthington, making strokes of 8 to 9 in. at the time the above particulars were taken. One reason for the evaporation being so low was that the boilers were being forced and the economizers had only one-half the heating surface they should for a plant of the size.

The best results will be obtained when there is a head on the suction side of the pump, but in any case this will be one of the factors governing the maximum temperature to which the feed can be raised.

Editorials

Memorizing Plant Details

Loose-leaf books and card catalogs incline the operating engineer to acquire a rusty memory regarding dimensions, sizes of equipment and other plant statistics of secondary importance. While his ability to turn out a kilowatt-hour at a low cost is not affected by his reliance upon records for these details, it is well to keep posted enough to answer questions bearing upon the installation with what might be called a zero factor of hesitation. Individuals differ in their capacity to retain plant statistics. One can do it without effort, whereas an equally good engineer may find it hard to recall anything beyond the nominal horsepower of the boilers and engines and the height of the stack.

Some may ask: "What is the good of memorizing such data as the dimensions of the turbine and boiler rooms, the wattage of the lamps used, their height above the floor, the inside diameter of the chimney, depth of stack foundations, size of engine cylinders, capacity of circulating pumps, etc., when all such information can be had from a notebook?"

There are many advantages, apart from the saving in time. Perhaps the most important are the mental discipline and the evidence which the ability to give quick and accurate replies to questions of detail gives of personal efficiency. When the superintendent or manager calls the engineer to his office, he can take along his notebook, but it makes a better impression if he can answer every inquiry for information of more or less settled character without referring to it. Busy executives like a subordinate whose mind is cultivated to hair-trigger precision in delivering routine information. Such evidence of quick thinking and retentive powers shows the fitness of the employee for his job and leads to promotion. Visitors to his plant appreciate an engineer's ability to answer leading questions "off the reel," and many times this has been a factor in the receipt of offers from other plant owners.

Burdening one's memory with data of only trifling value is useless, but a live operating man should know the rating, speed and fundamental dimensions of every engine, turbine, pump, boiler, fan and motor on the place, the size of grate surfaces, capacity of stokers, number and size of tubes in the surface condensers, diameters of intake and discharge piping, length and height of circulating-water conduit, size of steam-delivery outlets at boilers, header sizes, span of the traveling crane, flue cross-sectional dimensions entering the stack, capacity of tanks, bunkers, ashpits, etc. It is the statistics of operating significance that are the most useful, rather than dimensions of trifling consequence, such as the clearances between various systems of auxiliary piping at various points or the overall dimensions of a feed pump. When these minor data are wanted, careful measurements or protracted studies of plans and elevations are necessary and there is plenty of time for them.

What the engineer needs to have at his command are data upon which such matters rest, as the rush ordering of spare parts, the comparison of bids, interpretation of plant performance, critical study of unit apparatus, rough estimates of the cost and desirability of plant changes or additions, fitness of new machinery for a trial on the premises, and other problems of executive concern. In the collection and study of such data and in the mastery of vital statistics hinted at as desirable, the ambitious engineer will find ample opportunity to put his mind to good use and to fit himself in part thereby for larger service and correspondingly increased remuneration.

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The Question of Boiler Rating

In the lecture on "Modern Boiler-Room Practice," by a member of this staff and printed elsewhere in this issue, a timely word of caution on the question of high boiler ratings is sounded.

We believe that Mr. Stott, of the Interborough Rapid Transit Co., is the pioneer in the practice of operating boilers at very high ratings. With him, it was necessary to meet the rapidly increasing steam demands on the Fifty-Ninth Street power house. He showed that this could be done without materially increasing the investment charges. On some occasions, the boilers in the Fifty-Ninth Street plant have been operated at ratings as high as three hundred and fifty to four hundred per cent. Since this demonstration of the feasibility of this practice, the profession has applied it extensively, especially in central-station and railway power houses.

In 1903 each 5000-kilowatt turbine in the Fisk Street station of the Chicago Commonwealth Edison Company was furnished steam by eight boilers, each with 5000 square feet of heating surface. Based on ten square feet of heating surface as equivalent to one boiler horsepower, there was a total of 4000 boiler horsepower to 5000 kilowatts. This gives 1.25 kilowatts per boiler horsepower. A little later the same boiler capacity furnished 12,000 kilowatts, or three kilowatts per boiler horsepower. At present the ratio is about one to three and one-half.

In the Two Hundred and First Street station, New York City, thirty-six, 650-horsepower boilers are expected to care for 110,000 kilowatts, or 4.7 kilowatts per boiler horsepower. At the Detroit Edison Company's new station, the stacks and breechings have been so proportioned that in emergencies it is expected that three 2365-horsepower (rated capacity) boilers will care for two 20,000-kilowatt turbines. This gives the very high figure of 5.65 kilowatts per boiler horsepower.

While indulging in enthusiasm over the benefits of high boiler ratings, it is well, as the lecture points out, to consider the dangers that accompany the practice. The factors that determine how much a boiler may be overloaded are first, the scale-forming agents and suspended solids in the feed water; second, the thoroughness of the water circulation, and last, the amount of fuel which it is possible to burn per unit area of grate in a unit of time. The high overloads on marine boilers generally are contrasted with the usual loads carried by land boilers. It should be remembered that in marine practice the feed is mostly condensate and therefore free from scale-forming solids.

Some scale, when subjected to temperature variation, will crack off in places. When scale thus disengaged lodges on the tubes or shells of a boiler that is driven hard, serious bags usually result. At high ratings, the water boils so violently that scale, which may have become loosened, will sometimes be kept from contact with the shell or tubes, but when the boiler has ceased to steam rapidly, as when the peak load has passed and the fire is banked, the scale settles on the metal surface and the heat from the furnace walls and arches is sometimes enough to bag the tube or shell. Other tube troubles are the result of the effect of the blow-torch flame often produced in a fuel bed subject to high forced draft, the intensely hot flame impinging on one or a few tubes usually causes them to quickly overheat.

When high ratings are adopted, many forms of furnace trouble and repairs not anticipated will manifest themselves. High ratings have not yet become common in manufacturing plants, and before they do, let the engineers of these plants realize that where ratings of two hundred to three hundred and fifty per cent. are employed, the boilers are so operated for but brief periods, usually not longer than an hour and a half.

The aim should be, first, to install or use enough boilers to make it reasonably certain that one is not courting dangerous troubles. This means that the reduction of investment or overhead charges by practicing high ratings should always be governed by the consideration of safety.

Coal Analysis

There is much written (and more said which would not look well in writing) on the subject of coal analysis and coal specifications in general. The ultimate consumer—the engineer or fireman—and the chemist do not get together and understand one another thoroughly. In fairness to both, it should be conceded that each is honest in his effort, competent in his line, and has just reason for complaint that he is not receiving the hearty support and coöperation of the other, but it is probably true that each expects too much and gets too little, like the guest who, in his endeavor to relieve the anxiety of the hostess as to the dinner, said: "It is first rate what there is of it, —er, I mean there is a great plenty such as it is."

The user says the chemist's test is all right so far as it goes, but that it does not go far enough, or that he cannot tell how coal from which a given sample is taken will behave under conditions which are not known to the chemist, while the chemist feels that the user's reports are quite abundant such as they are, but not thoroughly good.

The main reason, as stated before, is that they do not enter enough into the work of each other. The fireman struggling with a coal not suited to his equipment, and therefore unable to meet the peak-load requirements, cannot be expected to enthuse over the report of the chemist that the sample shows the coal of the best quality, etc. He cares nothing about the chemical content so long as the steam pressure is up, and less when the pressure is down. The chemist is too prone to swear by his results and the engineer at them.

The chemist should remember that his function is to tell the chief elements in approximately the percentages in which they are found, and when the most satisfactory combination obtainable is arrived at by experiment and trial under the boilers, he is to see that fuel of this composition is delivered so long as operating conditions remain the same. A closer coöperation between the chemist and the engineer will go a long way toward perfecting the system of purchasing coal by specification.

A practical chemist, speaking of oils, once told the writer: "I cannot tell you what chemical characteristics the oil should have for your plant, but if you give me a sample of an oil which has proved satisfactory, I can tell you what it is composed of and see that the oil you get in the future conforms to it. If later, the oil does not seem so good, you may find that the trouble lies in the bearings or elsewhere, and not that the quality of the oil has changed." This seems to be the crux of the matter. The purchase of fuel on the present basis is vastly better than the wrangle with the dealer as heretofore. Let us have a more complete test coupled with observation when it is in use.

Accident Prevention

Another deplorable accident has happened in which two men were seriously and perhaps fatally scalded due to the prolific cause, a combination of inexperience and a hazardous occupation. Two men undertaking to clean a boiler, proceeded to remove the handhole plates before the boiler had been drained. "A torrent of hot water and steam gushed out upon them and the only means of escape was through a small opening." One became fastened and had to be dragged through.

Where lies the blame?

That the men themselves were at fault by reason of their negligence does not obtain if, as appears, it was known that they were inexperienced; if not known the fact might easily have been learned. It was obviously then the duty of someone to see that they were duly instructed and protected. Training men in their duties of whatever nature, in or about a power station, is the first essential to safety.,

Has the owner or his agent the legal or normal right to employ or allow an incompetent to jeopardize his own life or the lives of others? This question applies to all employments and positions in the plant. How is the employer to distinguish between the two? This forms the most complex problem and cannot be answered in such a way as to apply in all cases. But there is a vast difference between the known and confessedly incompetent and the man who, by reason of long experience, may be expected to do the right thing, but fails at some critical time. The deciding element too often is the wages for which the daily services of either can be obtained. Let there be more regard for human life.

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Suppose, as the cartoon this week suggests, Hero, or Watt, or any other of the forefathers of steam engineering should return, like "Peter Grimm" and visit one of our modern power houses. They sure would be some surprised!

Correspondence

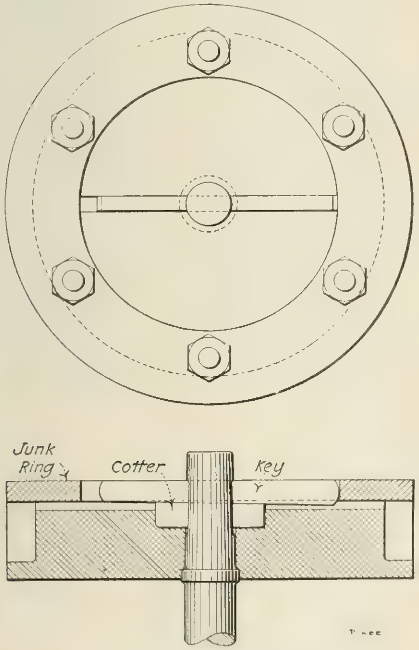
Fitting Pistons

I cannot commend H. P. Clarke's method of shrinking and riveting on pistons, as stated in the Jan. 14 issue. There is always some doubt as to the holding power. Further, it is applicable only to the smaller sizes of pistons, and even then it is not applicable to a tandem engine. These opinions are based on experience with many pistons, varying in diameter from 4 to 108 in.

I have always used one of the two following ways, favored by most engineers here, for securing the rod. For pistons up to 48 in. in diameter and having junk rings, tapering the rod, forming a shoulder and fitting a key and cotter, both of which are prevented from working out by the junk ring, as shown, are common and good practice. The junk ring must be taken off before the cotter and key can be removed.

The second method is to taper the rod and fit a steel nut having a castle head. The nut is prevented from turning as the split pin fits in a recess in the nut.

If the piston has, say, a couple of 1-in. holes drilled and tapped on each side of the piston eye, it is an easy matter to remove the piston by placing a heavy plate across the end of the rod (after removing nut and cotter) and using two long studs extending through the piston and the plate on the end of the rod. By putting a fair amount of tension on the plate, the piston will come away; if it happens to stick, a few heavy blows on the plate while the tension is on will be sufficient usually to start the piston. When a piston is well shrunk on the rod it is nearly impossible to get it off.



Old Method of Fitting Pistons

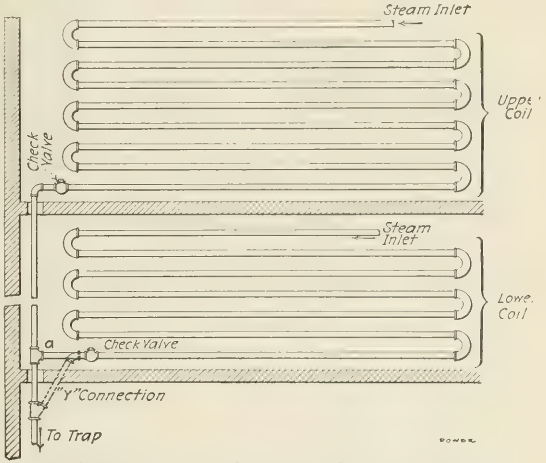
E. R. Pearce.

Rochdale, England.

* * *

A Troublesome Steam Coil

There were two drying rooms or ovens situated one above the other, each containing 1500 ft. of 1-in. pipe arranged on the sides of the rooms in the form of a box coil. Both ovens were connected to the main steam line carrying 150 lb. steam pressure, with a common return line to a trap, of the tilting type, located in the basement. The lower coil gave trouble; it would not drain properly, so that it was nearly always half filled with water, and the desired temperature could not be maintained in the oven.



Original and Changed Connections

I found that the coil was not air-bound, and that the trap was of ample capacity and working properly, so I traced out the drain-pipe lines and found them connected as shown in the sketch at *a*. After substituting a *Y* for the *T*, as shown by dotted lines, both coils worked satisfactorily.

C. E. Anderson.

Chicago, Ill.

* * *

Ill Advised Winding Changes

With an electrical machine of good design, which the operator has in no way undertaken to modify, the possible troubles are limited. If simple tests fail to disclose anything the matter with the machine itself, one may look to defective indicating instruments, overload, excessive voltage or some characteristic of the connected load.

A direct-current motor driving a centrifugal blower, gave commutation trouble that seemed to be due to the commutator distorting and to its bars becoming loose. Naturally the commutator was blamed and a new one was installed; but in a few days the new one gave the same trouble. A good commutator man, not supposed to know anything about general testing, diagnosed the trouble as due to excessive speed and proved his case by taking the speed with the bypass on the blower closed. All previous speed tests had been made with the motor under load and without observing the relation between the speed and the load. The so called full-load speeds, which had not proved excessive, were revealed to be really the speed corresponding to heavy overloads. At normal current load, the speed was actually 35 per cent. high and on no load the motor almost raced.

It seems the operator wanted to "speed the motor up a little," so he rewound the fields with a smaller size of wire, thereby not only producing excessive speed, but otherwise impairing the motor's commutation characteristics.

J. A. HORTON.

Schenectady, N. Y.

What Did the Engineer Get?

In the Mar. 10 issue, page 349, Warren O. Rogers cites a case where "Engineer Wise," on taking charge of a plant already in operation, saved his employers $135.20 per week, or $7030.40 per annum by changing the grade of fuel, making changes in machinery, etc. I wonder how much of this amount was added to the engineer's salary over and above what was paid by his employers to the man who preceded him in the plant.

It may seem sordid, but an experience covering many years has caused me to think it is as much the duty of an engineer to look after the condition of his own pocketbook as of that of his employer's. How about it?

W. H. ODELL.

Yonkers, N. Y.

Condenser Temperature and Pressure

It is well known to engineers that in any condenser the temperature of the air-pump suction is a few degrees below the temperature of the steam as it enters the condenser from the exhaust pipe. This difference is 30 deg. F. in some cases, and though sometimes mentioned in textbooks is but rarely explained; it is due to the impossibility of keeping the condenser absolutely free from air leaks.

The explanation of why the presence of air affects the temperature is as follows: Let it first be assumed that the pressure throughout the condenser is constant (it is practically so within small limits) and that the condenser contains a mixture of air and steam in a certain ratio. Dalton's Law of Gaseous Pressures states that the pressure of a mixture of gases is equal to the sum of the individual pressures of the gases which would result if each were to occupy the entire space alone. Hence, the pressure in the condenser is made up of the pressure due to the steam plus the pressure due to the air.

The entering steam consists of a mixture of water vapor and air in a certain proportion, but as soon as some of the water vapor is condensed the proportion of air to vapor is raised. Hence, the pressure due to the air increases while the pressure due to the water vapor diminishes, and this decrease in vapor pressure is accompanied by a corresponding fall in temperature.

For example, suppose there is a condenser pressure of 3 lb. per sq.in. absolute; 2 lb. per sq.in. being due to steam and 1 lb. per sq.in. to the presence of air. The steam temperature corresponding to 3 lb. per sq.in. absolute is 141.5 deg. F., while the actual temperature corresponding to a steam pressure of 2 lb. per sq.in. absolute is 126 deg. the final temperature is therefore 15.5 degrees lower than would be the case if the entire pressure was due to steam alone.

JOHN H. GEO. MORRISON.

Glasgow, Scotland.

Writing Specifications

Writing specifications of all power-plant supplies or parts of any kind is one of the best educational exercises possible. It is also of practical use. As a test of how much or how little attention is given to the details of any familiar object seen daily in the power plant, let the reader undertake to write, without consulting a book or a catalog, a complete, binding specification. A specification must hold even an unscrupulous bidder to exactly the thing wanted. It should avoid "freak" conditions or requirements, which if actually specified, would mean additional cost to manufacture and useless expense. Then let him compare what he has written with standard specifications and see how far short he falls.

Try something easy at first, for example, a cast-iron flanged fitting 14x8x10, with companion flanges covering the following in full:

1. Articles called for:
   Number
   For what pressure
   For what temperature
   What material:
      a Cast iron
      b Semi-steel
      c Cast steel
2. Test:
   a Kind of test
   b Pressure of test
   c Weight limits
   d Thickness limits
   e Where made and by whom
   f By whom paid for
   g Causes for rejection
   h Fillers allowed or not
3. Delivery:
   a When
   b Where
   c Whose expense
   d Final acceptance
4. Dimensions:
   a Face to face
   b Face to center
   c Diameter of flanges
   d Diameter of bolt circle
   e Thickness at bolt circle
   f Number of holes
   g Drill size of holes
   h Position to center line
   Packed joint:
   a Rough or smooth cut
   b Plain or raised face
   c If raised, diameter and height of face
   d If male and female, diameter and height of male; diameter and depth of female
   e If tongue-and-grooved, outside and inside diameter and height of tongue; outside and inside diameter and depth of groove.
5. Flanges:
   How to be attached to pipe:
   a Thread tapered or straight
   b For standard, extra heavy or double extra heavy pipe
   c Kind of thread, pitch and diameter
   d Screw joint
   e Screwed and peened in thread
   f Screwed and peened into chamfer
   g Shape and size of chamfer
   h Thickness of flange at thread
   i Peened without thread
   j Diameter of bore, shrunk or slipfit
   k Thickness on pipe
   l Chamfer shape and size
   m Calking recess—depth, large and small diameter
6. Bolts:
   a Size
   b Length
   c Kind of head, hex. or square
   d Kind of nut, hex. or square
   e Finish

While the foregoing appears formidable on first sight, it is in fact implied if not specified in any order for such a fitting; therefore if the fittings are wrong, it may be due wholly to lack of detailed specifications.

If the whole power plant is gone over in this manner, it will be a complete analysis which may never have been thought of before.

When something new is to be ordered, write a specification of it carefully and completely and there will be less to cause contention and dissatisfaction. Try it and see how well it works out.

LEON LEWIS.

New York.

Long Service of Gas-Engine Piston Rings

In our plant of four Westinghouse gas engines, which have been in constant service for 12 years, we recently had the cylinders of two of them rebored and fitted with new pistons and rings.

The last of the two to be rebored was a vertical three-cylinder engine, 14x18 in., and rated at 175 hp. One cylinder was in bad condition, having been scored, and it usually began to give trouble if a heavy load was put on it, while the left-hand cylinder has given unusually good service, the piston not having been out for about ten years until it was removed recently to rebore the cylinders.

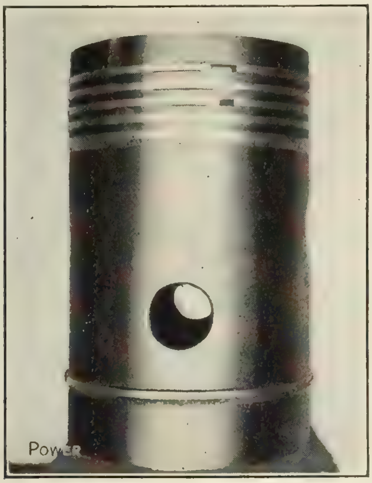


FIG. 1. PISTON AS IT CAME OUT OF CYLINDER

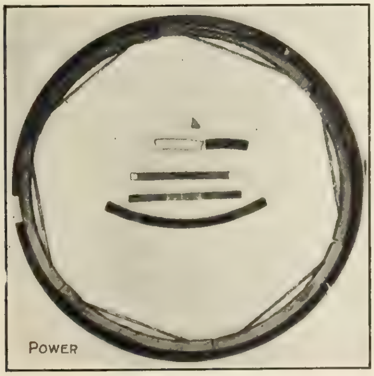


FIG. 2. OLD-STYLE SEGMENT RING

Fig. 1 shows the piston as it came out of the cylinder with the rings in place without disturbing the carbon deposit; all of the outside sections were free and could be moved around but were worn thin. The inner segments were held in the groves by the carbon deposit, but the carbon was not hard as it could easily be scraped out with a screwdriver. The piston had never shown any signs of blowing by the rings.

Fig. 2 shows one of the old-style spring segment rings found on the piston, showing it just as it was removed from the cylinder without the carbon deposit being disturbed; this can be seen on the inside of the segments. This type of ring has been obsolete for years, as it usually got carbon bound much sooner than any other type, especially if a poor grade of oil was used. In the center of Fig. 2 are three views of broken pieces of the outside ring.

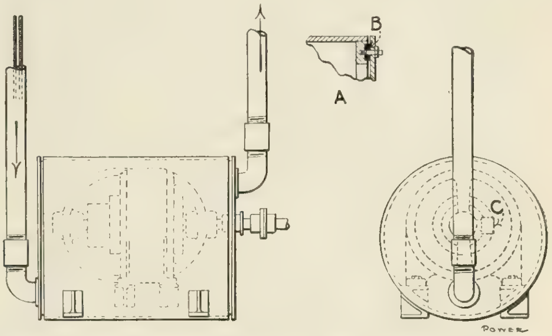
During the first eight years' service of this set of rings the engine ran six days a week and 16 hr. each day; the last two years the set has been in service every other day for the same number of hours each day.

L. M. JOHNSON.

Emsworth, Penn.

Submerged Motors

Motors built for submerged service are usually of special design and are large for their output in order that excessive heating may be avoided; these features make the cost high.



CASING FOR SUBMERGED MOTOR AND DETAIL OF JOINT

The arrangement here described employs a motor of the standard floor type, no changes being necessary in the patterns or in any of the windings; hence a quick shipment is easily made. The tube inclosing the motor is of thin sheet metal and rests on cast feet welded to it. Cast feet are also placed inside the tube upon which the motor rests, being welded to the tube in order to avoid bolt or rivet holes. A stuffing-box is provided where the shaft extends through the rear-tube cover.

The tube ends are of sheet metal and are fastened, as shown in detail at *A*. A bar of rectangular section is bent into a ring and then welded to the tube. Into this ring is turned a groove to receive the packing *B*. Studs and nuts are used, and to avoid possible leakage, the stud holes are not drilled through the ring. Attached to the covers or ends are iron pipes through which air is forced to the tube, insuring good ventilation of the motor. The air enters at the commutator end. The wires leading to the motor are inclosed in one of the pipes, so that no water comes in contact with them.

In order to insure good lubrication for long periods without the attention of the operator, an oil reservoir has been provided in addition to the regular one cast in the bearing housing. This additional oil chamber, shown at *C*, consists of a plain, closed cylinder, piped to the oil reservoir in the bearing housing.

Machinery of all kinds is invariably tampered with while idle by persons mischievously inclined, and electric motors are no exception. Such tampering would render an equipment useless at a time of emergency. By entirely inclosing the motor .this nuisance is avoided, especially where the motor is not continually submerged.

G. F. Weigand.

Elizabeth, N. J.

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Fairness to Understudies and Successors

Referring to your editorial on this subject, in the Mar. 10 issue, I am sorry that retiring engineers, whether they leave from choice or otherwise, frequently do give their successors all the trouble they can. Probably their idea is that, by so doing, they magnify their own importance. However, it is a poor policy and sometimes acts as a boomerang.

Some years ago the engineer of a drug mill left to take a situation at more pay, and his former employers got another man. The new man went to the factory on Sunday and, as the engineer who was leaving did not come near, he looked over the plant alone until he thought he had it well in hand. The plant consisted of a 12x24-in. engine and a boiler to correspond. The engineer did his own firing. The engine was of an old type, having poppet valves operated by a cam shaft parallel with the cylinder.

During the following morning, the firm I was with got word that there was something wrong with the engine, as they could not keep up steam, and I was sent to investigate.

When I got there, the engineer, a stranger to me, was doing his best in the fire pit, but the engine labored hard. I looked it over and found nothing hot. Then I went through the three-story factory but found nothing until I got on the roof and saw the exhaust. I knew then that the trouble was at the engine, and my first impression was that the former engineer had tampered with the piston.

While waiting for noon to make an examination, I noticed that the rollers on the end of the poppet-valve levers continued to roll even when the concentric part of the cam was passing, instead of clearing it. Evidently the rollers on the valve levers had been lowered enough to prevent the valves seating properly, thus causing continuous blow. As soon as I raised the rollers to clear the concentric part of the cams, the engine bounded to its work.

The new engineer was a good man, and no doubt would have discovered the trouble himself, but for the fact that he had to do his own firing and had no time for anything else until noon. To my mind it is mighty small business for a retiring engineer to play such a trick either maliciously or as a joke.

L. S. Williams.

Philadelphia, Penn.

*

Removing Frost from Direct-Expansion Coils

Relative to the discussion on this subject, and to the letter by A. G. Solomon, in the Mar. 17 issue, I offer the following:

Ammonia cannot condense and evaporate as it pleases without the transfer of a lot of heat. If hot gas is admitted to a cold coil, the gas will condense only after it has given out from 550 to 600 or more B.t.u. per pound, the exact amount depending upon the temperature and the pressure. One pound of hot ammonia gas will melt about 4 lb. of ice before all of it will be condensed. If liquid at 90 deg. F. is admitted to the coil, 1 lb. will melt about $^5/_{11}$ lb. of ice in cooling to 32 deg.—that is, it takes about nine times as much liquid as gas to do the same thawing.

Mr. Solomon's argument about the machine doing no work on the other coils because of lack of ammonia, was evidently got from experience in thawing frost with liquid, as a large quantity would be required; he would also have trouble getting that liquid out of the coils again. Mr. Solomon should be sure he did not drain the receiver of all liquid and then let gas into the coil through the expansion valve and thaw with the gas.

It is the same old notion, but in another form, that it is all gas beyond the expansion valve and that gas does the cooling. If it is proper to cool with gas, use liquid for heating. It is the change of state that gives out or absorbs heat. Changing from gas to liquid gives out heat; changing from liquid to gas absorbs it. The ammonia and steam condensers and steam radiators give out heat; the cooling coils and a steam boiler absorb it. The quickest and best way to thaw ice off a coil is to operate that coil temporarily as a condenser by supplying it with hot gas instead of with cold liquid, as in regular operation. As a consequence, long before the coil is full of liquid the frost will be melted off, or if very heavy, will be loose from the pipe and can be rattled off with a stick without danger to the pipe or the fittings. A good scraper will do the work, but it is more work and takes longer.

Harry D. Everett.

Fort Snelling, Minn.

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A Troublesome Engine Click

After an engine had been down for a general overhauling and was again started, a peculiar knock developed. It differed from the usual pound in being more of a metallic click. The engineer failed to locate the trouble beyond deciding that it must be in the cylinder.

He took the head off and found no clue, but on replacing the head he put a layer of thick paper over its surface, which changed the sound to a dull thud. On again taking the head off he found a slight indentation in the paper which showed that one of the nuts on the piston stood out farther than the rest. This nut was filed down, ending the trouble.

Sidney K. Eastwood.

Philadelphia, Penn.

Inquiries of General Interest

Piston Ring Diameter—For a 14-in. diameter cylinder how large should the ring be turned?

M. O. D.

The ring should be 14¼ in. in diameter before it is cut and sprung into the cylinder.

Poppet Valves—Why are poppet valves used on some large engines?

M. O. D.

Poppet valves are used because they can be made as balanced valves, and are readily operated to give a sharp cutoff.

Increasing Power of Engine—How can the power of a steam engine be increased?

G. J.

The number of horsepower which the engine can develop may be increased within the working capacity of its parts, by increasing the speed of the engine, or supplying the engine with steam at higher initial pressure, or by reducing the back pressure, as by use of a condenser.

Boiler with Superheater—What precaution should be taken in starting a boiler with a superheater?

M. O. D.

In starting up a boiler with a superheater, start up with the superheater "flooded," allowing the water level to lower gradually before the boiler and superheater get into regular use.

Dead Power Factor Meter Reading—When there is no current on the instrument where will the pointer of a power factor meter stand?

A. T. S.

As most pointers are mounted on jewels without springs, it will stand wherever it happens to be when the current is turned off.

Compound Engine Exhaust Pressure—If the cylinder ratio of a compound engine is four, and the cutoff at one-quarter of the stroke in the high-pressure cylinder, what will be the absolute terminal pressure in the low-pressure cylinder?

M. O. D.

Without allowing for drop or clearance it would be one-sixteenth of the absolute initial pressure in the high-pressure cylinder.

If the Governor Belt Breaks—If an engine governor belt should break would the engine run away or stop?

J. G.

Unless the engine is provided with an automatic stop valve or the governor itself is supplied with an automatic stop motion, more steam will be admitted to the engine than is necessary to keep up the proper speed and the engine will run away.

Height of Siphonage—What limits the height to which water will rise in a siphon?

B. A. N.

The water is forced upward in the rising leg of a siphon by the pressure of the atmosphere acting on the free surface of the water. The water will rise until the pressure due to the height of the water in the rising leg of the siphon and the pressure at the top of the siphon are together equal to the pressure of the atmosphere.

Aligning an Engine—How may a horizontal engine cylinder be squared with a line shaft in a building?

M. O. D.

Draw a line through the center of the engine cylinder, or parallel to the center line of the cylinder, and place the engine so that such a line will be square with a line stretched level and plumb under the center line of the line shaft at the same level as the cylinder center line, or the line which has been stretched parallel to the cylinder center line.

Beveled Safety Valve Seat—What is the advantage of having the seat of a safety valve beveled at an angle of 45 deg.?

M. O. D.

The advantage is that as soon as the valve lifts from its seat, a larger area is presented for the pressure of steam to act on the valve, thereby compensating for the reduction in pressure right at the point of release of the steam. Another advantage is that the valve and its seat do not wear away so rapidly, and the valve will thereby be kept tight longer.

Saturated Steam From a Superheated Supply—If a battery of boilers were fitted with a superheater and the whole output of steam were to be taken from one main pipe, how could one particular engine be supplied with steam that is not superheated?

M. O. D.

The steam for that particular engine could be carried off separately through an uncovered pipe and allowed to lose its superheat, if desired, before the steam is supplied to this engine, thereby reducing the steam to the condition of ordinary saturated steam.

Velocity of Pump Discharge—On page 314, Mar. 3 issue, is given a formula for figuring the velocity of a pump discharge against 80 lb. pressure. How could the velocity be calculated for other pressures?

D. F. B.

The mention of 80 lb. pressure was superfluous beyond indicating that the water pumped is a homogeneous liquid. Considering water as an incompressible liquid, for a given rate of pump displacement, the velocity or speed attained by the liquid when pumped through a given size of pipe would be the same for all pressures.

Furnace-Lining Trouble—The side walls of our boiler furnaces burn out very quickly down next to the grates. What causes it?

J. W. D.

If burning out of the firebrick is due to the material of the brick, as, for instance, presence of sand melting to glass, the trouble may be detected by examining whether slag has formed within the brick. If slag forms only on the furnace face of the firebrick, it is probably due to presence of silica (sand) in the coal or mixed with the coal. If the brick crumbles with a clean fracture the crumbling is due to expansion of some material or substance in the pores of the brick, probably water due to moisture in the brick when laid, or afterward absorbed.

Unit of Evaporation and Factor of Evaporation—What is meant by the terms unit of evaporation and factor of evaporation?

J. D.

The unit of evaporation is the common standard to which the results of boiler performances are compared, being the heat required to evaporate 1 lb. of water from a feed-water temperature of 212 deg. F. into steam at the same temperature, which, according to standard steam tables, is equivalent to 970.4 B.t.u. A factor of evaporation is the quotient which results from dividing the number of heat units necessary to evaporate 1 lb. of water under actual conditions of feed-water temperature and steam pressure, by the heat equivalent of a unit of evaporation, i.e., by 970.4 B.t.u.

Resetting Pump Rod Spool—If a spool slips on a pump rod how should it be reset?

M. O. D.

Move the piston rod of the side which carries the spool so the steam piston on the same rod strikes one end, and then move it so it strikes the other end, each time making a mark on the rod even with the end of the stuffing-box. Next find a point midway between the marks and move the piston rod into the cylinder until this mark comes even with the end of the stuffing-box. The piston will then be in the middle of its stroke. Then remove the valve-chest cover and set the rocker so that when the rocker arms and the valve rod of the opposite side of the pump are standing still the "lost motion" will permit the valve to be moved as far to one side of its central position as the other. When this condition is satisfied the spool will be in its right position on the rod, and can be fastened in place.

Engineers' Study Course

Elementary Mechanics--IV

LAST LESSON'S ANSWERS

11. When a body is regarded as acted upon by forces only it is called a "free body."

12. Yes.

13. Yes.

14. The conditions of equilibrium are that (1) the resultant = 0; (2) the summation of the horizontal components = 0; and (3) the summation of the vertical components = 0.

15. In Fig. 13 the force P_1 represents the force exerted by the steam on the piston, transmitted through the piston and connecting-rods, to the crankpin. The force P_2 might represent either the weight of a flywheel, or the rotating field, or armature, of a generator. The forces R_1 and R_2 represent the reactions offered by the main bearings, and the force P_3 could be either the weight of a pulley, or the weight of a flywheel, depending upon the type of engine and the nature of the load.

EQUILIBRIUM CONTINUED

If the three conditions of equilibrium, as stated at the close of last week's lesson, are thoroughly mastered by the student, but little trouble will be experienced in dealing with forces which produce a state of uniform motion or rest of a body. Referring to Fig. 10 in Lesson III, the force T is the resultant of OM and the force P, but this resultant T is balanced by the corresponding reaction of the crankpin on the connecting-rod. Therefore, since the forces are all in balance the resultant must equal 0. To find the force, then, required to balance a system of forces it is necessary (1) to isolate all the forces from the body on which they are acting, (2) to resolve these forces into their horizontal and vertical components, (3) from the components thus found to determine the resultant force, and (4) then the desired force will be a force which is equal and opposite to the above resultant.

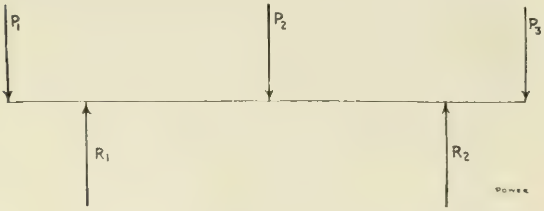


FIG. 13.

To demonstrate this principle take the ordinary type of flywheel governor, as shown in Fig. 14. As the engine speeds up, or slows down, the balls B and A move farther away from, or closer to the spindle OD. When the engine is running at a uniform speed the governor balls remain at a fixed distance from the spindle.

Let Fig. 15 represent one of the balls as a free body. The line OB is drawn parallel to the line OA and represents the resistance offered by the arm. The line OE is vertical and proportional to the weight of the ball A, and the horizontal line OF indicates the centrifugal force tending to pull the ball A in a straight line. Construct the parallelogram $BOENB$ and draw the diagonal ON, which is the resultant of the forces T and W. The centrifugal force exerted by the ball A must then be equal and opposite to the resultant ON, and when such a condition holds true all the forces are in balance and will continue to be so until the speed of the engine changes. This will change the value of the centrifugal force C and then the arm OA will take a new position until the forces again come into a state of equilibrium.

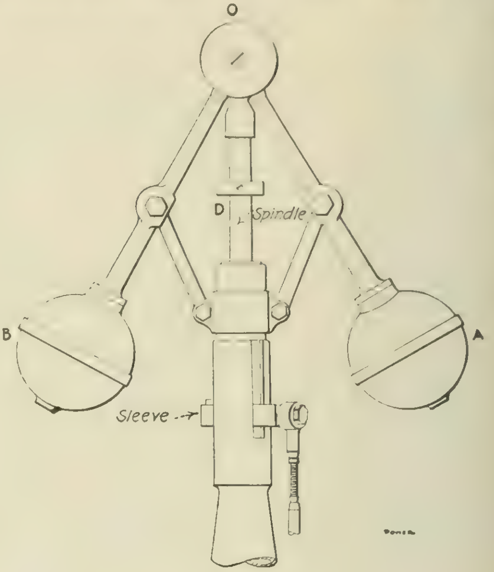


FIG. 14.

TRIANGLE OF FORCES

When three forces acting in the same plane keep a body in equilibrium the resultant of any two of the forces must be equal and opposite to the third force. For this to be true the third force must pass through the same point as the other two. *Therefore, when three forces acting in the same plane produce a state of equilibrium, these forces must pass through a common point.*

Example—Let Fig. 16 represent a common form of wall crane and assume the load as acting at the point A. This load W causes (1) a tension or pull in the tie-rod AC which is counteracted by the rod exerting a corresponding reaction T, from A to C; and (2) a compression or push in the beam AB, which is counteracted by the reaction P of the beam from B to A. From the previous discussion it follows that the resistance offered by BA is equal and opposite to the resultant of the tension in the tie-rod AC and the weight W.

Let Fig. 17 represent the point A as a free body. The line OG replaces the resistance offered by the beam BA, the line W replaces the weight W, and the line ON replaces the resistance offered by the rod AC. From the point N draw the line NH equal and parallel to the line W. Draw HO equal and parallel to OG. There is thus formed the triangle $ONHO$ in which it will be noted that the force T is acting from O to N, the force W from N to H, and the force P from H to O. In other words, the three forces acting on the point O have been replaced by a triangle which is called a *force triangle*. Hence the following rule can be stated:

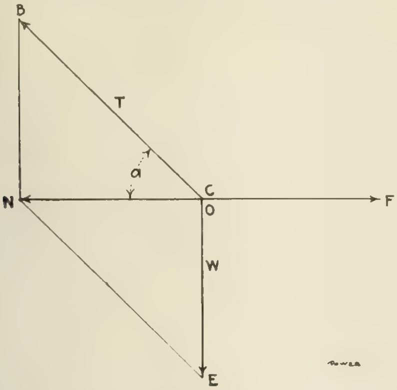


FIG. 15.

When three forces acting at a given point on a body are in equilibrium, these forces can be represented in direction and magnitude by the sides of a triangle taken in order, if the sides of the triangle are parallel to the respective forces. Conversely, if three forces acting on a body can be represented in direction and magnitude by the sides of a triangle taken in order, the forces will be in equilibrium.

This law is simply another application of the parallelogram of forces. The important part of the law is that the sides must be taken in the same order, or in the same way around. This law does away with the necessity of resolving forces into their horizontal and vertical components. Thus in the triangle $ONHO$ (Fig. 17) the angle NOH must equal the angle a (which is known) and the side NH equal the known weight or load W. The hypotenuse ON will then equal the unknown tension T in the tie-rod AC and the base OH will give the compression in the beam AB.

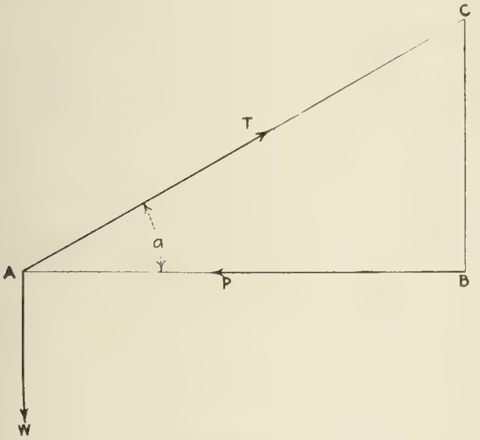


FIG. 16.

Example—Suppose the angle a (Fig. 16) is 30 deg. and the load $W = 1000$ lb.; what is the tension T in the rod AC, and what is the compression P in the beam AB? Use the force triangle of Fig. 17, letting the angle NOH = 30 deg. and the line NH = 1000 lb.

$$\sin a = \frac{NH}{ON} = \frac{W}{T}$$

therefore,

$$T = \frac{W}{\sin a} = \frac{1000}{0.5} = 2000 \textit{ lb.}$$

Also

$$\tan a = \frac{NH}{OH} = \frac{W}{P}$$

therefore,

$$P = \frac{W}{\tan a} = \frac{1000}{0.577} = 1732 \textit{ lb.}$$

This problem is comparatively simple because the triangle contains a right angle.

STUDY QUESTIONS

16. Two forces of 80 and 100 lb. act on a body and make an angle of 60 deg. with each other. Find the direction and magnitude of a third force to produce equilibrium. Assume the force of 100 lb. as horizontal.

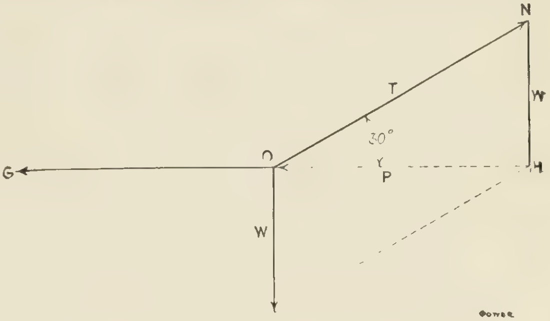


FIG. 17.

17. In Fig. 16 the tension T must not exceed 2000 lb. If the angle a is 35 deg., what is the maximum load that can be suspended from the point A?

18. In Fig. 15, if the weight W = 40 lb. and the centrifugal force C = 30 lb., determine the tension in the arm OB.

19. In Fig. 16, let the weight W be suspended at a point midway between the points A and B. Will the tension in the tie-rod AC be increased or decreased?

20. Will the pressure at the point B remain horizontal? If not, how could its line of action be determined?

⁂

To Teach Fuel Economy—To teach employees of the Northern Pacific Ry. system how to use coal economically, and how to avoid creating smoke nuisances, George T. Conley, fuel supervisor of the system, will deliver lectures at the principal stations on the line. Mr. Conley will travel in a special car fitted out to serve as a lecture hall, and it is estimated that he will consume more than a year in completing the course of instruction.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The Passing of a Bad Bill

By R. T. STROHM

Last week Josiah Barlow's Bill
Begun to work at Hooker's mill.
For he was such a gol-darned fool
It warn't no use to go to school.
They turned him loose with brush an' broom
To sweep an' dust the engine room.
About the time that he was through,
The guvner belt bust right in two.
Then that ole engine she cut loose
An' ran to beat the very deuce.
The engineer woke up an' swore,
An' then he beat it for the door.
But thinkin' he might save the mill,
He bellered, "Grab her throttle, Bill!"
Now Bill, poor dub, he couldn't see
Just where her throttle ought to be;
But he was willin', young and spry,
An' when the crosshead caught his eye
He braced his laigs an' took a breath
An' gripped it with the grip of death.
It rastled poor Bill to an' fro
Some eighteen thousand times or so.
His laigs went floppin' everywhere,
Now on the floor, now in the air.
It banged his bean down on the floor
Some twenty million times an' more
Before Bill got a little wit
An' thought he'd best let go of it.
But when he let it go at last,
Poor Bill was speeded up so fast
He slithered off acrost the floor
An' then out through the open door.
He took the pasture in a jump
An' sailed right by the village pump.
He bounced along the quiet street,
Now on his head, now on his feet,
An' so on through the big glass plate
Up at the store of Old Man Tate.
He knocked it into smithereens
An' come to rest among some beans
An' prunes an' rice an' other trash
So dry an' hard they couldn't smash.
Bill sot there for a little while
A-smilin' of a thoughtful smile,
An' while he thought he took a prune
An' absent-minded got to chewin.'
Then Old Man Tate he lost his head.
His face went white, his neck got red.
He yelled "Police!" an' Jacob Dunn
Come tearin' up street on the run.
Whenever Jake don't get too full
He is our local constabull.
He sorted Bill out from the beans
An' pulled a pistol from his jeans,
An' told Bill not to stop or talk
But step off at a lively walk.
Bill saw that balkin' was no use
An' marched off to the calaboose.
We thought the Court would make him pay
For bustin' up the store that way;
But sakes alive! Judge Adam Squeers
Gave Bill a term of seven years
For stealin' prunes from Old Tate's shop.
Sez he, "This wave of crime must stop!"
Bill took his sentence ca'm enough
But said he thought it kind of tough
To make him run so far an' fast
To get one measly prune at last.

⁂

"That's our general superintendent—son of the president—he began at the bottom and worked up—started in being an oiler, right after he left college!"

"When was that?"

"Oh, he graduated last June!"—"Puck."

Now, oilers, if your dad's a president, **show him the joke**—and you'll probably be worked up. If he's not, you'll be worked up, anyhow.

Buying Coal on Specification

By F. G. Lemke

In the plant the writer operates coal is purchased on the specification basis. All coal delivered must be of a quality equal or superior to the standard analysis for the various sizes given in Table 1.

TABLE 1 STANDARD ANALYSIS

Size of Coal	Per Cent. Moisture as Delivered	Per Cent. Ash in Dry Coal	Per Cent Volatile Combustible Matter in Dry Coal	Per Cent. Volatile Sulphur in Dry Coal	Heat Units per Lb. of Dry Coal
Egg	4	11	8	1¼	13,200
Stove	4	12	8	1¼	13,000
Pea	5	17	8	1¼	12,300
Buckwheat No 1	6	18	8	1¼	12,200
Buckwheat No 2	6	19	8	1¼	12,100
Buckwheat No 3	6	19	8	1¼	12,000

As it is important that the coal used should be as uniform as possible, any variation in size greater than allowed in Table 2 is cause for rejection.

TABLE 2. SPECIFICATIONS ON SIZE

Size of Coal	90 Per Cent. Should Pass through Square-Mesh Screen In.	90 Per Cent. Should Pass over Square-Mesh Screen In.
Egg	3	2
Stove	2¼	1½
Pea	¾	½
Buckwheat No. 1	½	¼
Buckwheat No. 2	¼	3/16
Buckwheat No. 3	3/16	3/32

A sample of the delivered coal is taken at the point of weighing; about 200 lb. for a 100-ton delivery. This is reduced by quartering to about 5 lb., which amount is put into moisture-proof receptacles, and taken to a specified laboratory for analysis to determine the percentage of moisture, ash, volatile combustible matter and volatile sulphur. The heat units are determined by means of a bomb calorimeter.

Correction is then made in the gross weight delivered, for any excess per cent. found over that allowed in the standard analysis, at the following rates:

For excess moisture, the gross weight is corrected by an amount directly in proportion to such excess per cent. For instance, an excess of 2 per cent. moisture will reduce the gross weight 2 per cent. and so on.

For excess ash, the gross weight (corrected for moisture) is reduced at the rate of 1 per cent. for each 1 per cent. of ash found in excess of the standard.

For excess volatile combustible matter, the gross weight (corrected for moisture) is reduced at the rate of 2 per cent. for each 1 per cent. of volatile combustible matter found in excess of that allowed.

For excess volatile sulphur, the gross weight (corrected for moisture) is reduced at the rate of 5 per cent. for each 1 per cent. of volatile sulphur exceeding that allowed.

For B.t.u. below that specified the gross weight (corrected for moisture) is reduced at the rate of 1 per cent. for every 100 B.t.u. below the specified amount.

All deductions for ash, volatile combustible matter, volatile sulphur and heat units are then added together and subtracted from the gross weight as corrected for moisture. The balance is the weight paid for. This method has given good results. No check analysis is allowed on moisture, as the first result is final.

⁂

Electrification of the Norwegian government railroads is the subject of a newly submitted report by a special commission. The excessive prices of imported coal (Norway having no coal mines) led to the investigation of the feasibility of using "white coal," and the electrification of seven trunk lines at a cost of $9,000,000 is recommended.

Causes and Prevention of Boiler Corrosion

By Francis H. Davies

SYNOPSIS—Internal and external corrosion, pitting, the forming of acids, electrolytic action and the use of zinc plates to retard its effect.

*

Under ordinary conditions of working the principal cause of steam-boiler deterioration is corrosion. Wasting may be said to commence immediately after the rolling of the plates, and through its entire life a boiler is continuously subjected to an insidious process of decay which is often difficult to locate and to prevent. Broadly speaking, there are three main forces which contribute to the gradual destruction of a boiler. The chief are chemical and electrical action, but mechanical movement or strain is also largely responsible. The effect of these actions is apparent both internally and externally, the former being more dangerous and complicated than the latter as the destructive forces at work are more numerous. External corrosion usually becomes evident before much harm is done, and almost without exception the cause is oxidization or rusting brought about by various means. Moisture is, of course, the root of this trouble, and its presence may be due either to exposure to the atmosphere, the careless use of water around the boilers, leaky seams and rivets or the absorption of water by the brickwork.

Of the careless use of water around the boilers the best example lies in the practice of quenching ashes when the fires are cleaned. A result is the formation of sulphuric acid which rapidly corrodes any metal it may come in contact with. Should it collect on the plates in its earlier forms of SO_2 or SO_3 it is harmless, but any small leaks which may occur at seams or rivet heads will add to the trouble at once by providing the necessary moisture. Such small leakages are generally ignored as they do not in themselves constitute a serious source of weakness and are often difficult to calk, but if left unattended it will only be a question of time for the combined eroding and corroding actions to produce a more serious state of affairs. It must be borne in mind that rusting or oxidation is greatly facilitated by heat and also by the presence of carbon in the form of coal dust. Add to these moisture to an appreciable degree and the result is the formation of ferrous carbonate on the plate, which in turn is oxidized and changed into ferric oxide. Carbonic acid is liberated during these chemical reactions and in conjunction with oxygen from the air assists in decay of the metal.

In Lancashire boilers, external corrosion is most marked in the flues and close to the brickwork. The latter is capable of retaining a great store of moisture, and hence the well known and dangerous result of corrosion at the seatings. Should the boiler be situated on damp ground it is essential that it should be provided with a good concrete foundation as this is the only means of keeping out moisture which rises from the ground. So far as the brickwork is concerned, the best plan is to place sheets of iron between it and the boiler, in which case the sheets alone will be attacked. Owing to the destructive action of lime when wet, clay mortar only should be used in close proximity to the plates. Flue corrosion arises from the fact that the gases are rich in the products of sulphur and carbon, which in the presence of moisture form a powerful corrosive agent.

So far only chemical action has been considered, but it is also necessary to take into account the equally destructive electrical action which is the natural sequence of the chemical effects. Iron oxide is electro-negative to iron, and the two in conjunction with even the smallest amount of moisture form an active electric cell which rapidly eats away the metal. This is particularly the case in flues where the electrolyte formed by the combination of flue gases and moisture is, electrically speaking, more highly exciting than moisture alone. The same effect is noticeable in iron coal bunkers, where the contact of wet coal with the plates sets up electrical action and eats away the latter, but perhaps the best example of electrolytic corrosion is provided by brass or gunmetal fittings, such as water and pressure gages, check valves, etc. The unequal expansion of the two metals gives rise to leakage, and this provides the remaining essential for the formation of an electric cell. In such cases corrosion is often rapid and subsequent trouble will be avoided if such fittings are from the first thoroughly looked after.

Internal corrosion presents a more difficult problem than the foregoing, as the number of destructive forces to take into account is greater. Grooving is well known to be a serious disease, which, arising in the first place from faulty construction and too rigid staying, is greatly aggravated by corrosion. There is a considerable difference in the temperature of the top and the bottom of a furnace tube, which consequently tends to arch. This should be and generally is provided for, but if expansion is too greatly restricted by staying, the plates of the furnace tube are subjected to severe stress, and, unless very ductile, the continued repetition results in cracks which usually occur at the furnace end. The fresh metal thus exposed is immediately attacked by any acids which may be present in the water and the original crack is in course of time developed into a groove. This serious defect cannot be remedied without somewhat drastic alterations in the construction of the boiler, but further weakening may be prevented by judicious reinforcing of the plate.

The familiar phenomenon of pitting may arise from several causes, both chemical and electrical. During the process of rolling the plates small pieces of carbon and slag are sometimes forced into the metal, and when these come under the influence of the water in the boiler, electrolytic action is at once set up and the metal in close proximity to the fragment of scale is eaten away. There are, however, more common causes than this, and perhaps the most prevalent arises from oil in the feed water. An animal or vegetable oil decomposes into various acids when subjected to heat, and these naturally attack the plates, particularly in positions where the emulsified oil has settled upon them. There is no excuse for the employment of such oils in engine cylinders as the harm they effect is well known, but the fact remains that through a mistaken idea of economy they are still often employed knowingly and perhaps more often unwittingly as adulterants in mineral oils. Cheap oil in a condensing plant is always a mistake, as boiler corrosion is an inevitable sequel. Pitting is often found internally opposite the lines of seating, and in this case it arises from the comparative coolness of these portions and the presence for a longer time of the occluded gases in the water. Also, there is little doubt that it is accentuated by electrolytic action arising from the difference in temperature of the two parts of the plates. Such temperature difference acts upon the molecular structure of the metal in such a way that the part of the plate at the higher temperature becomes electro-positive to the cooler part, and the former is consequently corroded. The same effect is found in furnace tubes at the sides, and generally. cases of pitting which seem inexplicable may often be traced to this cause.

General wasting and pitting arise from the presence of air or oxygen in the water, the plates being attacked and an oxide or scale formed. Iron does not rust in pure and dry air or oxygen, neither does it corrode in pure distilled water entirely free from oxygen, but if both are present as must necessarily be the case in ordinary practice, the result is that natural wasting which terminates the life of a boiler by simple old age.

For the purpose of retarding electrolytic action, it is customary to place in the boiler zinc plates connected electrically to the shell. The principle is to deliberately set up electrolytic action between the two, but the zinc suffers, being electro-positive to iron or steel, and the boiler shell is protected from the electrically exciting action of any acids that may be present in the water. There is no question that this is an effective way of mitigating corrosion, but everything will depend upon the manner in which the arrangement is installed. It is quite useless to place a zinc slab in a boiler without any electrical connection, although this is frequently done; neither will it be effective to suspend the slab from some convenient stay by a loose piece of wire. A sound and substantial electrical connection with the shell must be made, and the best arrangement is to nut down several zinc slabs to studs screwed into the sides of the furnaces or combustion chambers. The slabs should be about 1 in. thick and should each have an area of, say, 60 sq.in. The contact surfaces should be thoroughly clean and bright, and the nut screwed up hard enough to keep moisture from finding its way between them. This is a much more satisfactory arrangement than that of attachment by wires, soldered or otherwise, since such connections are in the way during cleaning and seldom have sufficiently ample contact surface.

For a new boiler satisfactory and effective protection will be obtained by using the proportion of 1 sq.ft. of zinc to every 50 sq.ft. of heating surface, but as the boiler ages this proportion may safely be reduced to 1 to 75 or 1 to 100.

* *

Alignment and Care of Turbo-Generators

By H. M. McLellan

A perfect alignment must be secured and maintained between the rotating parts of the turbo-generator set. Any out-of-alignment causes wear on the coupling faces and tends to create vibration. Special care must be taken that plenty of oil is conveyed to the coupling faces through the oil holes provided for that purpose. Lack of sufficient lubrication at this point will cause excessive wear in the coupling, with consequent vibration. Ordinarily, the clearance between the two halves of the coupling should not be less than $\frac{1}{32}$ in. with the halves as close together as the bearings will allow, when cold.

Bearings must always be adjustable so as to secure the best possible alignment. The working clearance in the bearings should be as small as possible, and should not exceed 0.01 in. The end clearance must also be small, not exceeding $\frac{1}{32}$ in. on each bearing for the exciters, and from $^3/_{64}$ to $^5/_{64}$ in. on each bearing for the generators. The end clearances may, of course, be increased where end motion is prevented by the coupling. Also the thrust shoulders on the shaft should be generously proportioned.

Care must be taken that the oil is retained in the bearings, and does not escape or creep along the shaft and get into the generator windings as it will eventually destroy the insulation.

The stator must be set magnetically central with the rotor, both longitudinally and radially. The longitudinal position can best be determined by running the set excited and adjusting the position of the stator until all end thrust is eliminated. When this position is obtained, the stator should be securely doweled to its base. When erecting on its site, it will generally be sufficient to divide the clearance between the rotor and the end covers equally at each end, as these clearances are usually adjusted to suit the magnetic center when on the testing floor of the manufacturer. In no case should these clearances be materially altered without first referring the matter to the makers.

A perfect balance in the rotating parts must be obtained. In many cases where there is difficulty, the trouble is not due so much to lack of balance as to a lack of proper alignment, imperfect fitting of coupling, or excessive clearance in the bearings; hence the necessity for eliminating all chance of trouble by proper attention to these points when erecting. If it is suspected that the trouble is due to the rotor being out of magnetic balance, this can be determined by running the machine unexcited, and comparing with the balance when excited.

Of course, the brushes must be properly bedded, and have the faces clean and smooth, and kept from chattering. If sparking takes place, the cause should be ascertained and removed, as a continuance of this trouble will rapidly destroy the brushes and also the surface of the slip rings or commutator. The mica between the bars on the exciter commutator should be filed down, and copper picking by the brushes should be stopped by using paraffin on the commutator, running without load until it has taken a polish. Trouble which cannot immediately be remedied on the brush gear should be reported to the maker, as it is cumulative in its effect and rapidly destroys the brushes and collecting gear.

Sparking at the brushes may be due to any of the following:

(1) Brushes may be jammed in holders.

(2) Brushes may require facing up.

(3) Brushes may be pressing too tightly on the slip rings.

(4) The rings may be rough. If so, they should be smoothed off. The rings should run smoothly and true with a dark, glossy surface.

(5) The machine may vibrate excessively, due to poor foundations, or to the revolving field being out of balance.

(6) The rings may be dirty or oily.

When brushes used with radial-type slip rings are made to lie at an angle other than 90 deg., the direction of rotation should be against the angle.

The machine should be kept clean and free from oil and moisture. Compressed air may be used for blowing out dust or dirt, at a pressure usually not exceeding 40 lb., and care should be taken that the air contains no moisture.

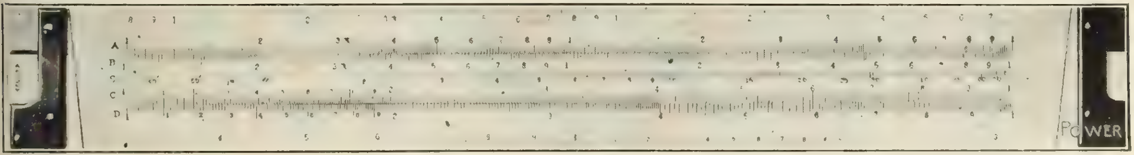
All insulation washers or collars, or surface insulation, should be given special attention and be wiped clean whenever necessary. All screws, connections and terminals on the machine must be kept tight. If any connections or terminals show signs of becoming dirty or corroded, their ends as well as the contact parts must be thoroughly cleaned.

⁂

Engineers' Improved Slide Rule

By D. E. Foster*

The customary way of obtaining the circumference of a circle on the ordinary slide rule is to place the figure 3.1416 of the C scale opposite the figure 1 or 10 on the D scale. This process may be simplified by the addition of a second D scale placed on the edge of the rule beneath the regular D scale, with the figure 3.1416 of the new scale in line with the figure 1 above it on the regular D scale. By setting the cross-hair over the given diameter on the regular D scale, the operator can find the circumference at once on the scale below.



Improved Slide Rule with Extra Scale Top and Bottom

One of the usual ways of obtaining the area of a circle on the rule is to set the figure 1 or 10 on the C scale opposite the given diameter on the D scale. The result is then found on the A scale opposite the figure 0.7854 on the B scale.

Another method is to place the figure 0.7854 on the B scale under the figure 1 on the A scale. The area is then found on the B scale after the cross-hair has been placed over the given diameter on the D scale.

These processes may be simplified in a manner similar to the one described above by the addition of a second A scale located on the upper edge of the rule above the regular A scale, and set to the right a distance sufficient to make the figure 0.7854 of the new scale lie directly over the figure 1 of the regular A scale. By setting the cross-hair over the diameter on the D scale, the result may be found on the new A scale.

A glance at the illustration will suffice to show how these results may be accomplished. The cross-hair indicator is not shown in the figure, as it was removed to facilitate the photographic work necessary to build up the illustration.

The advantage of being able to obtain the circumference and the area of a circle at a single setting of the cross-hair without moving the slider is evident. There is another advantage, however. Suppose one wishes to know the area of a circle when he has the circumference. He sets the cross-hair on the figure representing the circumference on the new circumference scale and reads the area of the circle on the new area scale. At the same time he may read the diameter on the D scale and the area of a circumscribing square on the B scale. Hence it is evident that if one of these four functions is known, the other three may be determined by one setting of the cross-hair. There are a number of other common problems that will be considerably shortened by the use of these two new scales.

⁂

Auld's Safety Valve

A design of safety valve, the invention of David Auld & Sons, Ltd., Glasgow, is illustrated herewith. It is of the class adapted to allow overpressure steam to escape from the full area of the main valve or nearly so, the main valves being opened by the steam pressure acting on one side of a piston secured to the main valve when the pressure on the other side of the piston, which maintains the valve in the closed position, is relieved by auxiliary-valve opening by the action of the overpressure on a piston secured to the auxiliary valve. In this design only one cylinder is employed for the two pistons, which are connected to the main valves, and fitted to move simultaneously in opposite directions, while a cage arrangement is adapted to hold the moving parts in position while permitting them to be easily withdrawn for inspection or repair.

Fig. 1 is a front elevation of a double safety valve, Fig. 2 is a corresponding side elevation partly in section, and Fig. 3 is a front sectional elevation. The inlet A and the outlet B are formed by the casing of the valve, and are separated by that portion forming the cylinder C.

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*Professor of mechanical engineering, State College of Washington, Pullman.

Within this cylinder are fitted the pistons *D* and *E*, which are formed in one with the two main valves *F* and *G*. A guide pin is screwed into the piston *D*, and enters an eye in the piston *E* to act as a guide and steady the motion of the pistons. The seat for the valve *F* is formed on the casing and the seat for the valve *G* on the cage device *H*. Regulating springs are fitted around the spindles of the main valves. The auxiliary or regulating valve consists of a valve *J* connected by a spindle to a piston *K* below which is always open to the steam pressure through the duct *L* leading from the boiler to the chamber *M*. The valve spindle is hollow above the valve and is formed with a piston *N* to balance the valve *J*. A spring is provided for controlling the action of the valve *J*. The steam is led from the space between the pistons *D* and *E* by the port *O* and duct *P* to a chamber *Q* below the regulating valve *J*.

The action of the valves is as follows: Fluid pressure enters the main-valve casing by the inlet branch *A* and flows along the ports or ducts *R* into the space between the main valves *F* and *G* and main pistons *D* and *E*. The fluid pressure also leaks past the main pistons into the space *S* in the main cylinder *C*, thereby acting on the opposite sides of the main pistons and holding the main valves tightly to their seats. The fluid pressure in the space *S* between the main pistons passes through the port *O* and duct *P* to the chamber *Q* under the regulating valve *J*. The inlet pressure also passes by the port or duct *L* to the chamber *M* and acts on the underside of the piston *K* connected to the regulating valve *J*. This regulating valve is loaded to a predetermined pressure by means of the spring shown, and immediately the inlet pressure tends to exceed this amount the regulating valve *J* is forced off its seat by the pressure on the piston *K* and under the valve overcoming the force exerted by the spring. On the regulating valve *J* opening the pressure contained in the space *S* between the main pistons is exhausted through *O* and *P* reducing the pressure.

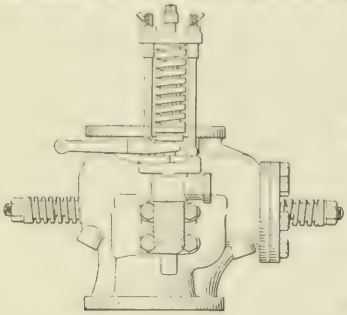


FIG. 1

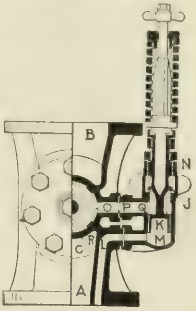


FIG. 2

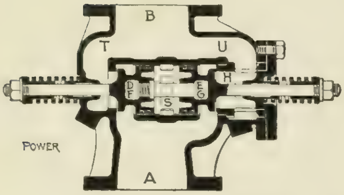


FIG. 3

Details of Auld's Safety Valve

Although the pressure under the regulating valve *J* is altered by this action the adjustment of the regulating valve is kept constant by the inlet pressure constantly acting under the piston *K*. The pressure contained in the space *S* between the main pistons being considerably reduced, the initial pressure acting on the annular part around the outside of the main pistons overcomes the pressure holding the main valves on their seats, thereby opening the main valves. Fluid pressure now flows through the valve seats into the outlet branch *B* from the valve *F* by the duct *T*, and from the valve *G* through openings in the cage device *H* and duct *U*. When all the surplus pressure has been discharged the spring closes the regulating valve *J*, shutting off the escape of pressure from the space *S* between the main pistons, wherein the initial pressure then accumulates and closes the main valves by acting on the main pistons. The same cycle of operations is repeated so long as the inlet pressure tends to rise above that to which the regulating valve is set. When the regulating valve *J* is opened by means of the hand easing gear provided, the main valves will be opened in the same manner as when the regulating valve *J* automatically opens, due to overpressure.—*The Mechanical Engineer*.

⁂

Three-Wire Generator with Revolving Compensator

The adoption of a revolving compensator with one collector ring for obtaining the neutral connection with three-wire operation is embodied in a design recently brought out by the General Electric Co., superseding the familiar separate stationary compensator and two collector-ring arrangement. The revolving compensator consists of a circular magnetic core upon which are mounted suitable exciting coils, the core with its coils being assembled on a cast bracket bolted directly to the back end of the armature spider, as shown in Fig. 1. The compensator fits under the overhanging end windings of the armature, projecting only a short distance beyond the main winding.

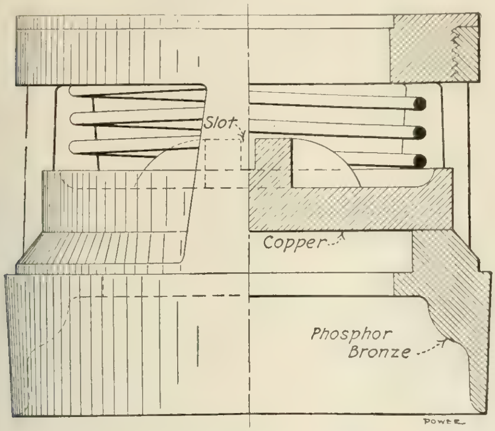
The compensator windings are connected to the main armature winding at proper points, and the neutral connection is taken through the armature spider to a single collector ring mounted on the outer end of the commutator shell. This ring may be seen in Fig. 2. The neutral brushes bearing on this ring are supported by and insulated from the main brush-holder studs. The simplicity of this design, self-contained with the armature, eliminates floor space taken by the stationary compensator, requires fewer collector rings and brushes and reduces the number of cable leads to the switchboard. These generators are of the commutating-pole type.

⁂

The Construction of Large Brick Chimneys is a job for skilled workmen. The taper, which sometimes changes several times in the height of the stack, is determined by a templet of triangular form, having a plumb line and bob on the vertical side and a spirit level on the horizontal (top) side, the third side being cut to the proper angle. The work is checked frequently by the inspector, who makes measurements of the interior diameter. The bricklayers work on a platform supported by two or four cross timbers. An upright post fastened to the inside of the stack projects above the platform and carries a horizontal timber (with inclined braces), having a pulley at each end. The hoisting line from an engine on the ground passes over these pulleys and down inside the stack, the material being hoisted generally on the inside. If it is to be hoisted on the outside the cross timber is made long enough to carry the pulley clear of the base of the stack. (From a paper by E. E. T. Tratman, read before the National Brick Manufacturers Association.)

T and R Pump Valves

A new design of pump valve and valve seat has recently been placed on the market by Tryon & Reid, 67 Montgomery St., Newburgh, N. Y.



Valve and Seat Casing

The seat and bushing, which is fitted to the valve deck of the pump, has its inside thread at the top in which a cap is screwed to keep the valve spring in place.

The copper or brass valve disk has a flat seating surface. The three brackets between the base of the bushing and the top of the cage keep the valve in place, which insures proper seating, and its saucer-shape top prevents the bottom of the spring from working out of place. This design allows the valve disk to raise to a sufficient height to discharge freely. The stem is eliminated and there can be no wear at the center of the disk.

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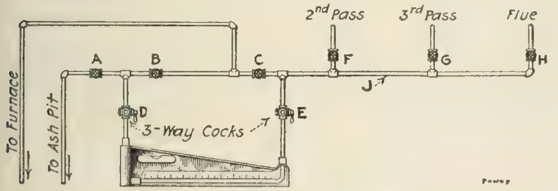
Draft-Gage Piping

By D. McGregor

The accompanying sketch shows how a boiler may be piped to a differential-draft gage to obtain the various readings and be adaptable either to forced- or natural-draft conditions. The arrangement requires ¼-in. pipe fittings, six straightway and two three-way cocks; the latter can be made out of regular cocks by drilling a small hole through the side of the body and half-way through the plug when set open.



Piping and Valves for Draft Gage

Following is a list of readings and how they are taken; all cocks are to be closed except those mentioned.

For the ashpit pressure, open the valves *A* and *BD*, straightway, and the three-way cock *E* to the atmosphere.

For the furnace pressure, open the *BD* valves, straightway, and the valve *E* to the atmosphere.

For furnace suction, open valves *CE*, straightway, and valve *D* to the atmosphere.

If it is desired to determine the drop in draft through the fuel bed, open *AC* and *DE*, straightway.

For the drop in pressure from the ashpit to the second pass, open the valves *AF* and *DE*, straightway.

For the drop from the ashpit to the third pass, open the valves *AG* and *DE*, straightway.

For the total available draft from the ashpit to the flue, open the valves *AH* and *DE*, straightway.

For the drop through the boiler from the furnace to the second pass, open the valves *BF* and *DE*, straightway.

For the drop through the boiler from the furnace to the third pass, open the valves *BG* and *DE*, straightway.

For the drop from the furnace to the flue, open the valves *BH* and *DE*, straightway.

For the draft at the second pass, open the valve *D* to the atmosphere and *E* and *F*, straightway.

For the draft at the third pass, open the valve *D* to the atmosphere, and *E* and *G*, straightway.

For the draft in the flue, open the valve *D*, to the atmosphere, and *E* and *H* straightway.

Unless otherwise stated, the valves *D* and *E* are opened straightway from the draft gage.

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Newark N. A. S. E. Holds Big Meeting

On Monday evening, Apr. 6, Newark No. 3 Association, of the National Association of Stationary Engineers, held a banner educational meeting. When about 200 members and visitors attended an illustrated lecture on "Modern Boiler Room Practice," by Charles H. Bromley, associate editor of "Power."

The presence at the meeting of Harry C. Cosins, first National President, one of the founder of the N. A. S. E. and the present national president, James R. Coe, gave added interest to the occasion.

Although the lecture was not to begin until 8:30, the hall was overcrowded long before this. It was necessary to remove a portable partion between the main and rear halls to accommodate those present. The associations of New Jersey showed their interest in the occasion by being represented by several members each, many men coming from as far south as Perth Amboy. Several engineers from New York and Brooklyn were also present.

Number three association has entered this lecture for the prize offered by the National officers.

Recent Court Decisions

Digested by A. L. H. Street

Validity of Contract for Joint Use of Poles—A telephone company, having encountered difficulty in securing authority from a city to erect poles and wires along a street, agreed orally with an electric company, which had existing poles, that if the electric company would permit it to erect poles for the use of its wires in place of the electric company's poles, it would permit the electric company to put up and keep its wires, etc., on these poles and on any other poles owned by the telephone company on other streets. Dispute having arisen between the companies, the telephone company sued to compel the electric company to remove its wires from the former's poles. In affirming a decree which dismissed the suit, the Kentucky Court of Appeals recently held in this case (East Tennessee Telephone Co. vs. Paris Electric Co., 162 "Southwestern Reporter" 530) that although the contract was originally invalid under the Kentucky statute which requires agreements not to be performed within one year from their making to be reduced to writing, this invalidity was cured by part performance of the agreement, the telephone company having erected the poles and the electric company having installed its wires thereon. But the court decided that the electric company did not acquire a perpetual right to use the other company's poles, and that the telephone company might bring a new suit to terminate the contract upon terms equitable to the electric company, if it can show that the public will be better served by an abrogation of the agreement. Touching the right of the electric company to grant the right to the telephone company to occupy the street, the court said: "The privilege of using the streets of a city cannot be granted by one public service corporation to another public service corporation. It can only be acquired in the manner pointed out in section 161 of the Constitution. So that, unless the telephone company had acquired from the city the right to occupy Main Street, it did not secure by its contract with the light company anything of value, because the light company had nothing to give it."

Nature of Government Water Power Privileges. The legal status of a contract by a water power company to construct a lock and dam for the Federal Government in a stream, in consideration of the privilege of using the water power produced by the dam in generating electric power, was involved in the recent case of the United States vs. the Chattanooga & Tennessee River Power Co., 209 "Federal Reporter" 28. In deciding that such an improvement constitutes "a public work of the United States," within the meaning of a federal statute which prohibits a contractor for such work from requiring or permitting any laborer or mechanic employed thereon to work more than eight hours in any calendar day, except in case of extraordinary emergency, the United States Circuit Court of Appeals said:

"The acts authorizing the contract, and the contract itself, provide for the construction of an efficient lock and dam in the Tennessee River; and the power company is required to and does undertake at its expense to furnish everything (save only the plans and certain specified materials which the Government is to furnish), and to do all that is necessary to accomplish this result, and to vest title to the whole in the United States; and the power company does this in consideration of receiving from the United States a grant of 'such rights as it possesses to use the water power produced by said dam, and to convert the same into electric power or otherwise utilize it,' for a specified time, subject, however, to the condition that 'nothing shall be done in the use of the water' from the dam to interfere with navigation or with the Government's use and control of the water for that purpose. This clearly limits the grant to the use only of surplus water. If, instead of this, a money consideration had been agreed upon, there could be no question touching the character or ownership of the work; indisputably it would have been one of the public works of the United States. Can it be that the medium of payment can operate to change this result? It is true that this surplus-water privilege is in terms to continue for 99 years; but this is subject to the right of revocation upon payment of the reasonable value of such necessary property as the company may acquire for the enjoyment of the privilege, the value of the 'franchise hereby conferred' being expressly excluded. Thus the surplus-water privilege is at most a determinable franchise; and this is further burdened with an obligation of the power company to 'furnish the necessary electric current while its * * * power plant is in operation to move the gates and operate the locks and to light the United States buildings and grounds, free of cost to the United States.' Now it is not the purpose to minimize the practical value of this privilege while it lasts. The attempt is simply to ascertain and define the nature of the privilege. For it is urged that the main object alike of the enactments and the contract was to produce this surplus-water power privilege and acquire part of the benefits of it, and that the lock and dam were a mere incident. It would be anomalous if the government were to regard its powers concerning navigable waters as entitling it to build locks and dams in navigable streams for the sole purpose of producing water power for the benefit of private persons; and yet this is the logic of counsel's insistence."

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Committee on Electrolysis

A joint National Committee on Electrolysis has been organized with Bion J. Arnold, of Chicago, as chairman and the membership made up of representatives of the various industries concerned. The object and scope of the committee's work is best explained as set forth in the address of Calvert Townley at the New York meeting in February. Mr. Townley said in part:

Electrolytic controversies have in the past given rise to unnecessary and acrimonious disputes, and not infrequently have resulted in litigation between the corporations concerned. The usual procedure in disputes of this kind has been for each side to employ one or more electrical experts who generally disagree as to the cause of the trouble and the remedies therefor. The dispute sometimes gets into the newspapers occasioning unpleasant notoriety and resulting in more or less drastic municipal action by the city government concerned. Much of this could be avoided if a body such as this committee could be created which would consider broadly the questions covered by the controversy, without attempting to pass upon the questions at issue, but to report back to their respective organizations so that in time the committee would come to be recognized as a neutral body whose decisions would be authoritative, the same as the Standards Committee of the American Institute of Electrical Engineers in connection with matters of definition and standardization.

Mr. Townley stated that in correspondence he had had with different people, the purpose of the committee was frequently misunderstood, that the impression prevailed in some cases that the committee was going to act as an arbitration board on controversies, and would tell what ought to be done, thereby taking the place of executives or the courts.

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Lecture for Eccentric Firemen on Boiler-Room Methods

On Tuesday evening, Mar. 31, about 400 engineers and firemen of the Eccentric Firemen's Association, attended an illustrated lecture on "Boiler Room Methods," by Charles H. Bromley, associate editor of "Power" at the headquarters in East Forty-fifth St., New York City. Mr. Bromley dealt entirely with the practical side of combustion, the troubles met and their remedies.

After the lecture, Marcus M. Marks, president of the Borough of Manhattan, told of the important work now under way in the various city departments. Timothy J. Healy, president of the firemen's association, presided at the meeting.

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A Manual of Electrical Testing is the subject of a new 48-page bulletin, issued by the Wagner Electric Mfg. Co., of St. Louis. Besides describing the line of portable instruments manufactured by that company, the publication describes various types of electrical instrument movements, the errors to which they are subject and gives suggestions for their handling and care. The methods of making electrical tests on alternating- and direct-current motors and generators and on transformers are described at length and illustrated.

The bulletin may be had upon application to the Wagner Co.

The 1913 "Proceedings" of the American Water-Works Association have just been issued in a cloth-bound volume of 750 pages, which is obtainable from the secretary, John M. Diven, Troy, N. Y. It contains a complete report of the papers and discussions delivered at last summer's convention in Minneapolis, including, among other subjects: "Rates and Rate Making," "Hydraulic Engineering Education," "Fire Protection Service," Turbine Pumps," "Prevention of Water Waste," "Modern Filter Practice," "Methods of Cleaning Reservoirs," "Mechanical Cleaning of Mains," "The Minneapolis Filter Plant," "Mobile Water Supply," "Memphis Water Supply," "Reservoir Design and Testing Mains."

ENGINEERING AFFAIRS

Jersey City and Newark N. A. S. E. associations had interesting lectures recently on "Power Costs in Central Stations and Isolated Plants," by H. H. Edgerton, who will be remembered as the expert statistician engaged by Governor Hughes to obtain 80-cent gas for New York City.

PERSONALS

John Huyette, resident inspector at the Brooks Works of the American Locomotive Co., has ben transferred to the Richmond, Va., plant in the same capacity, and John Gill, special boiler inspector at the Brooks plant, has been promoted to fill the vacancy left by Mr. Huyette.

Elliott H. Whitlock, with 18 years' experience in the carbon industry and the management of plants in other lines, together with a broad practical knowledge of engineering, has opened an office at 1506 West 112th St., Cleveland, Ohio. Mr. Whitlock is a member of the American Society of Mechanical Engineers, the American Electrochemical Society, the Cleveland Engineering Society and the Verein Deutscher Ingenieure.

POWER

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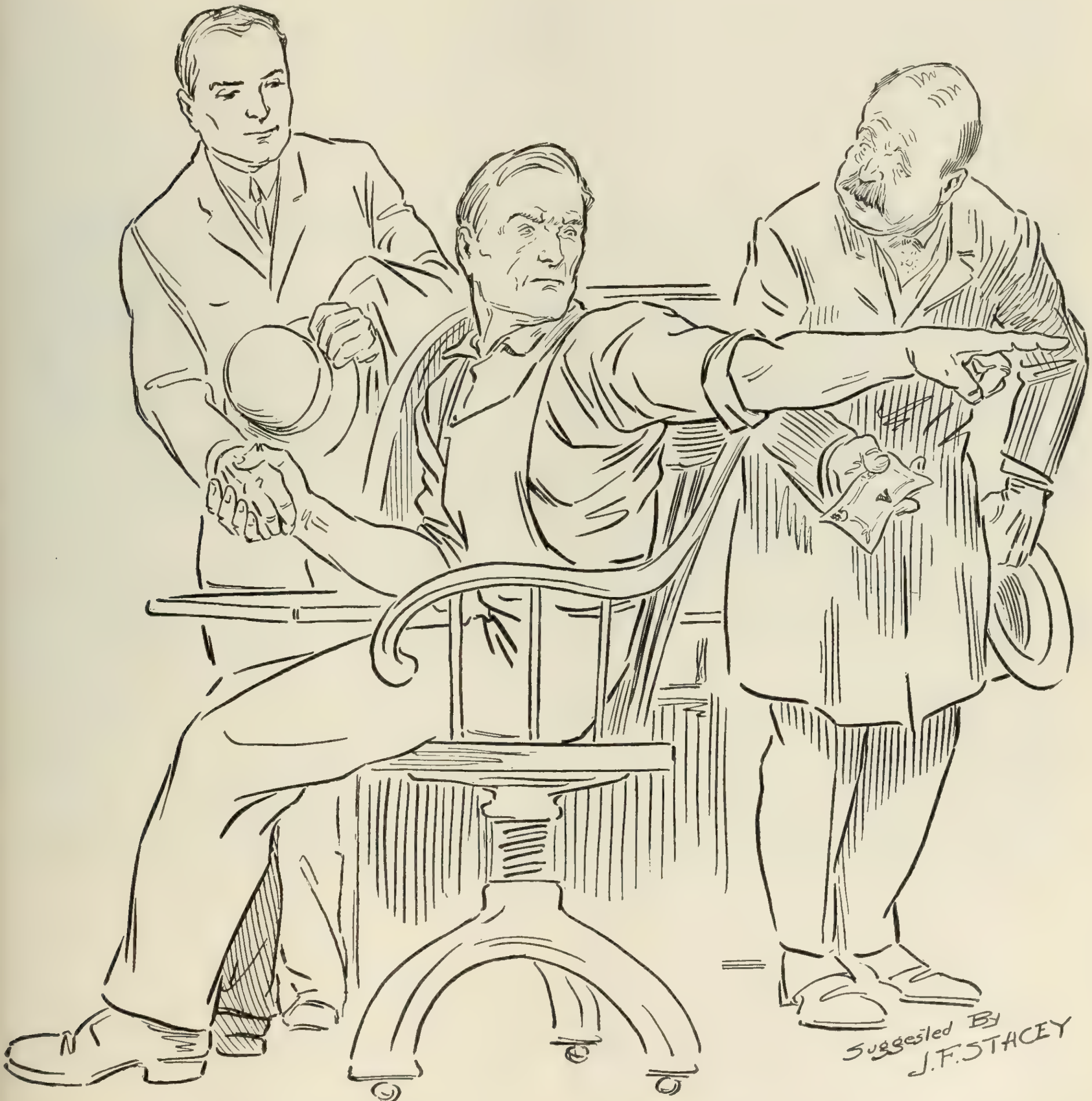

HONEST GOODS ARE SOLD BY HONEST METHODS

Improvements in Stand-By Station at Greenfield, Mass.

By Warren O. Rogers

SYNOPSIS—A steam-turbine stand-by plant used as a distributing station; it is tied in with a hydro-electric station and one other steam plant. Additional energy is purchased for 0.5c. per kilowatt-hour, which is less than the cost of coal at the steam plant.

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Although hydro-electric power plants have advantages over steam stations as to operation and maintenance costs, there is the necessity of maintaining a steam stand-by station to safeguard the services against serious interruption. This is the practice of the Greenfield (Mass.) Electric Light & Power Co., which operates a hydro-electric power plant at Gardner Falls, on the Deerfield River, and also maintains a stand-by steam plant at Greenfield.

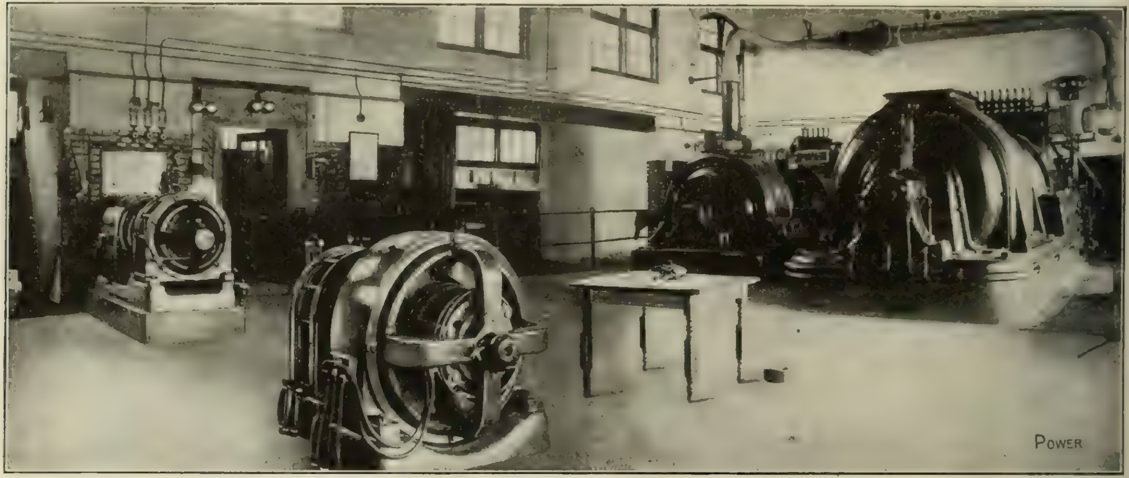

Fig. 1. Partial View of the Greenfield, Mass. Stand-by Station. The 750- and 2000-Kw. Turbines Are Shown in the Background

The water plant originally had two 400-kw. generators, but recently two 1450-hp. turbines and two 1170-kv.-a. generators have been added to the equipment. The new units operate at 150 r.p.m. under a 37-ft. working head. There is also a 135-hp. hydraulic turbine, driving a 60-kw. exciter. The cost of the improvements at the hydro-electric station was $60,250, divided as follows: Water turbines, $11,500; electrical apparatus, $29,500; switchboard and incidentals, $15,000, and for alterations to the building, its foundation, etc., $4250.

In addition, changes have been made in the Greenfield steam station, there having been installed two 500-hp. porcupine boilers, costing $11,500, and a four-stage, 2000-kw. Curtis steam turbine for about $30,000, a total of $41,500. For both the steam and hydro-electric plants, the total improvements have cost $101,750.

The original steam plant consisted of a 635-hp. Stirling boiler and a reciprocating engine. Later, three 250-hp. porcupine boilers and a 750-kw. five-stage turbine were installed. The engine has been removed and the Stirling boiler is held as a stand-by unit. The plant contains six boilers with a total boiler horsepower of 2385. The two turbo-generators have a total capacity of 2750 kw., as against 3140 kv.-a. at the hydro-electric plant.

The small steam-turbine unit generates 2300-volt, three-phase, 60-cycle current, at 1800 r.p.m., with 130 lb. steam on the turbine. The larger unit runs at 1800 r.p.m. and generates current at the same voltage.

Exciters

There are three exciter units, one turbine-driven, and the others motor-driven. The turbine unit is a 25-kw. turbine and a 25-kw. direct-current generator delivering 150 volts at 3600 r.p.m. This unit is used only when all the others are in operation and all lines are dead. The smaller motor-driven units consist of a 30-hp. induction motor and a direct-current 125-volt generator at 900 r.p.m. The other 50-kw., 125-volt, direct-current generator is driven by a 75-hp. induction motor at 1200 r.p.m. The main units and exciters are shown in the general view, Fig. 1.

Boiler Room

The vertical boilers are set with dutch-oven furnaces. Three are hand-fired and two have chain-grate stokers, two to each furnace, with a firebrick wall between each, extending the length of the furnace. Each stoker is but 3 ft. 3 in. wide and is 15 ft. 6 in. long, 50.4 sq.ft. or a total of 100.8 sq.ft. of grate area per boiler. The boiler-heating surface is 5900 sq.ft., or 58.8 sq.ft. per square foot of grate surface.

The three smaller boilers each have 2949 sq.ft. of heating surface, with a grate area of 7½x8½ or 63¾ sq.ft.;

this gives 46.3 sq.ft. of heating surface per square foot of grate area. The 635-hp. Stirling boiler contains 5688 sq.ft. of heating surface, with a grate area of 133 sq.ft., or 42.6 sq.ft. of heating surface per square foot of grate.

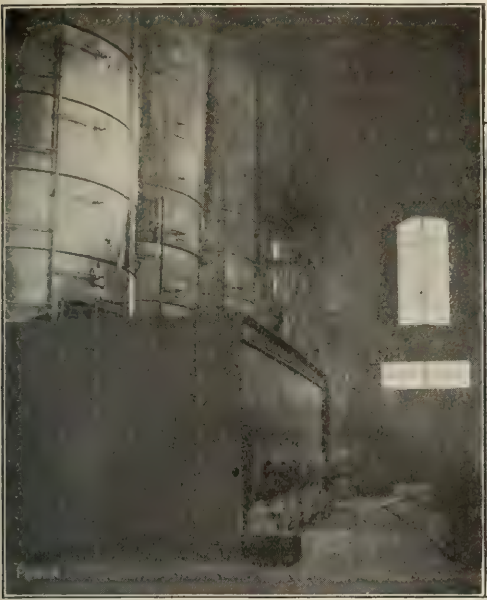

Fig. 2. Five Porcupine Boilers and Dutch-Oven Furnaces. Two Are Stoker and Three Hand Fired

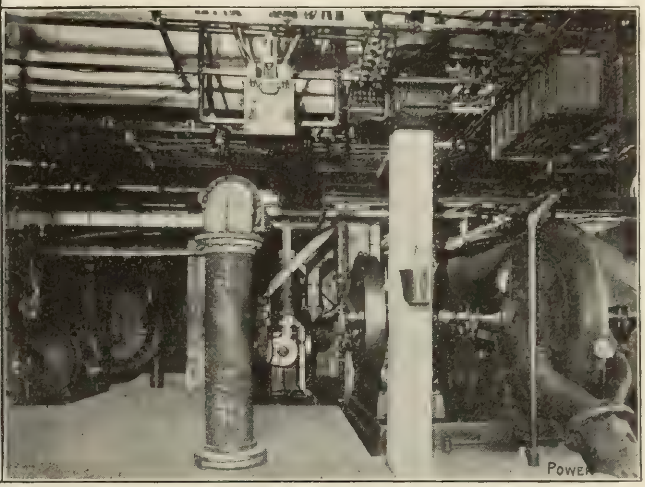

Fig. 3. Jet and Surface Condenser Equipment in the Basement. The Resistance Boxes and Wiring Are Hung from the Ceiling

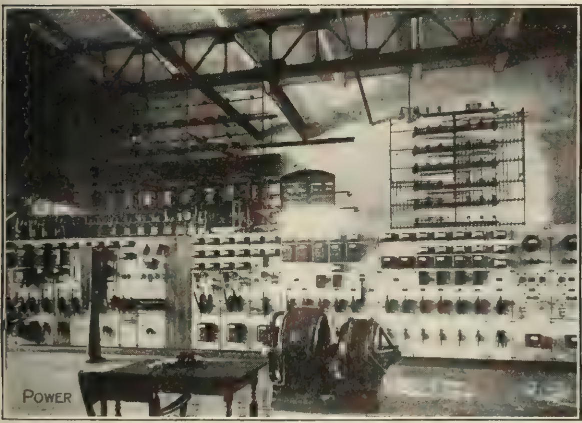

Fig. 4. Main Switchboard. The Wiring at the Right Is for 11,000-Volt Current

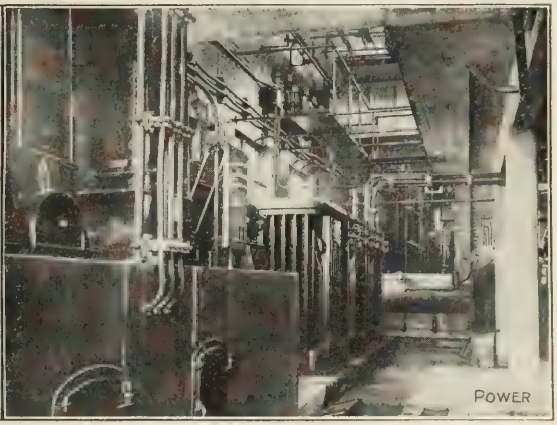

Fig. 5. Oil- and Air-Cooled Transformers in the Basement

The stoker-fired boilers, it will be noticed, have a higher ratio of heating surface per square foot of grate area than the hand-fired boilers. A view of the porcupine boilers is shown in Fig. 2.

Condensers

The small turbine is served by a jet condenser. The injection water is supplied by a 12-in. volute pump, turbine-driven. The dry-air pump has 8 and 18 by 12-in. cylinders and runs at 180 r.p.m.; it can also be operated with the large turbine condenser as a wet-air pump.

The large turbine exhausts into a two-pass surface condenser, having 6000 sq.ft. of cooling surface, or 3 sq.ft. per kilowatt of the turbine rating. The surface condenser is supplied with circulating water by a 15-in. centrifugal pump, driven by an 8x10-in. horizontal reciprocating engine at 200 r.p.m. with a capacity of 5250 gal. of water per minute. The condenser equipment is shown in Fig. 3. The condensing water was formerly pumped to the station, but it now comes by gravity.

Transformer and Converters

The rotary converters are in a room adjoining the turbine room, but about 4 ft. lower. These units consist of two 200-kw. rotary converters with a direct-current output at 600 volts and 1200 r.p.m. There is also one synchronous condenser floating on the line with a starting motor mounted on the shaft extension. A general view of the main switchboard for controlling these and other units is shown in Fig. 1.

Out in the condenser basement there are three 300-kw., 11,000 2300-volt, air-cooled transformers. The two cooling fans are each driven by a 2-hp. motor. This apparatus is placed on a concrete shelf, as in Fig. 5, with the air ducts encased in the concrete. The three 250-kw. transformers are oil cooled and transform from 11,000 to 2300 volts; they are placed on a concrete platform slightly raised above the basement floor. The mercury arc rectifiers are shown at the right, back of the supporting pillars. In a separate building there is a 270-cell storage-battery system, which works in parallel with a booster set and aids the station over peak loads.

Pumps

The boiler-feed pumps consist of one 9 and 6 by 12-in. duplex outside-packed unit and one turbine-driven triplex, 3-in. centrifugal pump with a capacity of 200 gal. per min. at 2500 r.p.m. The feed water is heated in an open heater.

Electrical Transmission

In connection with the steam plant, which is only run occasionally, there are the Gardner Falls hydro-electric plant and a steam plant at Easthampton; and a substation at Northfield. These plants are situated to give a strategic position with reference to neighboring developments and from the standpoint of economical production of electrical energy.

In addition to what energy is developed in the three plants of the company, surplus energy is purchased from the hydro-electric plant of the Turner Fall Power Co. at about 0.5c. per kilowatt-hour. This is less than the cost of coal used at the Greenfield station when running at full capacity. By using this purchased energy in addition to that generated at the Gardner Falls plant throughout about eight months of the year, the cost of electrical energy to the Greenfield company is said to be lower than for most other plants in the state.

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Gas-Producer Testing

By Everard Brown

SYNOPSIS—Maintaining test conditions, taking readings and samples and working up results of test.

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In order to establish the maximum efficiency of a gas producer, it is necessary to run a test of sufficient duration to give positive results under different conditions of operation. For example, various depths of the fuel bed and of the different zones should be tried as well as different blast pressures and quantities of steam, etc. It is a certain combination of these that will give the best results. If it is desired to experiment still further, different grades of coal can also be tried, in order to determine which, all things considered, gives the best results.

Weighing the Coal

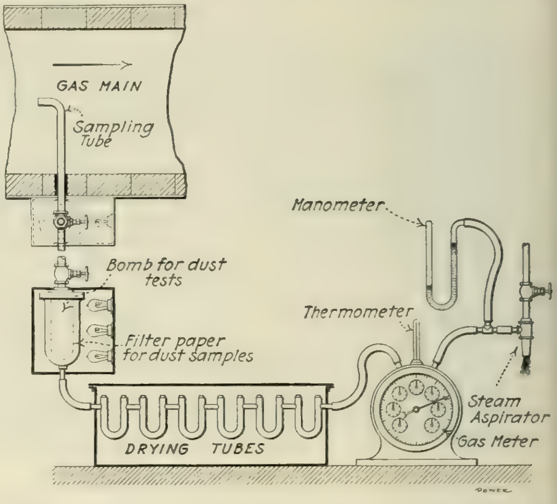
The simplest way is to place a box that will hold, say, 500 lb. on a platform scales at the top of the producer and convenient to the hopper. Coal can then be shoveled into the box and weighed and then shoveled into the producer hopper and charged as the rate of gasification demands. Each box of coal should be noted on the records. Small samples for analysis should be taken from each boxful and placed in a comparatively tight storage box.

Both proximate and ultimate analyses are desirable. If it is not convenient to make them within a short time after taking the samples, take separate samples for moisture determinations and make these determinations at once.

Fuel Bed and Zones

There are three distinct zones in a gas producer: The ash, the combustion and the distillation zones, and the proper depth of each is important.

The depth of the fuel bed and the uniformity of distribution can be ascertained by inserting a small-diameter pipe or rod through the poke holes at the top. It is well to slip a loose flange over the pipe or rod so as to cover the poke hole and prevent excessive leakage of gas. Marks filed on the rod and spaced 6 in. apart will greatly facilitate the work of taking these readings and reduce the chance for errors. These dimensions from the top of the fuel bed to the top of the producer, subtracted from the total dimension (from the top of the blast cone to the top of the producer) will show the total depth of fuel above the cone. If possible, measurements should be taken at several points both near the shell and toward the center of the producer.



Arrangement for Sampling and Testing Moisture and Tar in Gas

To measure the depths of the various zones, a similar method may be used. In this case push the rod down through the fuel bed until it strikes the top of the blast cone and leave it there for three or four minutes, then withdraw it and measure the different depths indicated by the colors of the rod. The rod will show three distinct zones or colors; the ash zone appearing black, the combustion zone yellow and the distillation zone dark red.

Two rods should be used simultaneously for these determinations, one at the center and the other near the shell to determine the fuel distributions. Both the fuel depth and zone depth measurements should be taken about every half hour.

Samples and Analysis of Gas

Gas samples should be obtained from the main about 20 ft. from the top of the producer so that the gas may be given an opportunity to become thoroughly mixed.

The simplest apparatus for taking these samples consists of a small piece of ¾-in. pipe, one end having a tee. To one side outlet of this tee attach a nipple to which the aspirator bottles can be connected by rubber tubing; in the other side insert a plug. The object of this tee is to permit of cleaning.

If possible, the gas samples should be taken continuously, or at frequent intervals, and as soon as a full sample is obtained it should be analyzed. If this is not convenient, seal the sample bombs with paraffin; if well prepared, the samples taken during the night can be analyzed the next day.

Gas Temperatures

Gas temperatures can be measured by means of a thermo-couple and an indicating galvanometer. The couple should be inserted into the main near the producer and kept there continuously during the test except for a few minutes about every 10 hr., when it should be removed to clean the soot off the protecting tube. To make corrections for the increased resistance, due to the heating of the "cold junction" of the couple above its calibrated zero mark, a mercury thermometer should be so suspended that its bulb will rest on the junction, thus showing to how much this heating amounts.

Soot and Tar

The apparatus necessary for sampling the soot in the gas consists essentially of a sampling pipe, a bomb or holder for filter paper, a supply of filter paper, a wet-gas meter and a steam-aspirating attachment.

A piece of ¾-in. pipe having one end bent at right angles may be used as a sampling pipe. To the other end attach a valve and a short nipple. A plug can be screwed into this open end when not in use. To the nipple connect the bomb or holder containing the filter paper and this in turn to the wet-gas meter. The steam aspirator is, of course, attached to the outlet side of the meter. To prevent condensation in the bomb it should be incased in a wooden box in which there are sufficient incandescent electric bulbs to generate enough heat to keep the temperature above 212 deg. F. It is also advisable to provide the meter with a thermometer and a manometer, or gage, so that the temperature and pressure of the gas can be noted. This arrangement is represented in the sketch.

The samples are usually taken in the following manner:

First insert the bent end of the sampling pipe in the main as near to the producer as possible, with its orifice pointing against the direction of flow. Connect up the rest of the apparatus and place the filter paper, after being carefully weighed, in its container and turn on the lights. When the wooden box is heated, the valve on the sampling pipe can be opened and the steam is turned into the aspirator. See that the sampling pipe does not become clogged.

As large a volume of gas should be sampled as the filter paper will permit; this should be at least 3 cu.ft. When the paper has become so clogged with deposited matter that it is almost impossible to aspirate any more gas, this soot and tar are dried, weighed and analyzed for carbon and hydrogen. It is necessary to take soot and tar samples only two or three times a day.

The method outlined will not give an absolutely true sample of tar, but the error involved is insignificant. The inaccuracy is due to the gas containing some tar in the form of vapor, and as long as the pores of the filter paper are open, some tar vapor will pass through. This fact can be observed in the discolorization on the under side of the filter paper after some of the gas has passed through.

Moisture Determination

The apparatus required for determining moisture in the gas is the same as that for soot and tar, with the addition of a series of calcium-chloride tubes inserted between the filter and the meter. To get samples of a larger volume of gas, cotton may be substituted for the filter paper as it will allow more gas to pass through before becoming clogged. In this case especial care should also be taken in heating the bomb so that no moisture will be absorbed by the cotton.

There should always be at least six drying tubes to insure the precipitation of all the moisture in the gas. This can be ascertained after a sample is taken by examining the last tube through which the gas passes. If it contains no moisture, or only a trace, the indications are that the gas is dry. Some tar vapors may also be condensed and are indicated by the discolorization of the calcium chloride in the first three or four tubes. This cannot well be avoided.

The tubes are weighed and the difference between this weight and that of the tubes before taking the sample, is the weight of moisture contained in the volume of gas passed through, as shown by the meter. After each sample is taken some of the tubes should be cleaned, dried and refilled. By doing this in rotation each tube is put into good condition for every third or fourth sample taken, thus insuring more accurate results. The samples for moisture should be taken alternatively with those for soot and tar.

Pressure and Quality of Steam

The pressure of the steam for blowing the producer is determined from the gage which should be carefully calibrated before and after the test, and which should be connected near the steam nozzle.

The weight of the steam can be calculated from Napier's formula for the flow of steam through nozzles; namely,

$$W = \frac{P \times a}{70}$$

Where

W = Weight of steam per second;

P = Pressure in pounds absolute;

a = Area of nozzle in square inches;

70 = A constant for all pressures above 25 lb. absolute.

A separating calorimeter will establish the quality of the steam with sufficient accuracy.

OTHER PRESSURES AND TEMPERATURES

To ascertain the gas pressure a water manometer should be connected to a short pipe inserted in the gas main near the producer and in such a way that friction losses will be a minimum. The atmospheric pressure can be recorded by means of a barometer.

A psychrometer or an ordinary wet-and-dry-bulb thermometer will determine the temperature and humidity of the atmosphere. This should be placed near the blower of the producer and if a wet-and-dry-bulb thermometer is used, care should be taken to keep the covering of the wet bulb well moistened at all times.

Steam- and gas-pressure readings should be taken every 10 or 15 min.; the other readings need not be taken so frequently.

ASH SAMPLES

These samples can be stored temporarily in a box having a capacity of about 100 lb. so that, at the end of the test, the total samples taken will fill the box. From this quantity two or three average samples should be taken and analyzed for carbon and iron. The samples should be taken at intervals not exceeding an hour.

TABULATING RESULTS

Probably the best way to tabulate the results is by showing graphically the hourly averages; one set of curves showing the gas temperature and pressure, another the steam pressure and weight of steam blown; another the pounds of coal gasified per square foot of grate area and the pounds of coal gasified per hour; another the heat value and composition of the gas, and another the depth of the distillation, combustion and ash zones.

A ready analysis of the results can be made by plotting these sets of curves, one above the other, on the same sheet of cross-section paper, so that respective ordinates will indicate simultaneous readings for all.

Other conditions being equal, the carbon dioxide and hydrogen curves will generally rise with the steam curves and *vice versa;* also the gas temperature and carbon-monoxide curves will fall with a rise in the steam curves. The hydro-carbon curves, in general, rise as the gas temperature falls and fall as this temperature rises, thus showing that they suffer decomposition at the higher temperatures. This fact is further borne out by the soot determinations because invariably the quantity of soot per unit volume of gas is large when the gas temperature is high.

It may be rather difficult to form a definite conclusion as to what combination of events is most favorable to the production of good gas, as a gas that is best for one purpose is not always best for another. In general, a good producer gas is one in which the sum of the carbon gases approaches 36 per cent. of the total gases. Of this percentage about 3 per cent. may be incombustible in the form of carbon dioxide. Such a gas would analyze about as follows: CO_2, 3 per cent.; CH_4, 3.5 per cent.; CO, 29 per cent.; H_2, 12.5 per cent.; N_2, 52 per cent.

It must also be remembered that the best producer is not always the one that generates the greatest volume of gas; in fact, the volume of a good producer gas should hardly exceed 85 cu.ft. per pound of carbon gasified.

The carbon loss in the ash and soot is another point that must not be overlooked because this can often be controlled. Usually, carbon losses in the soot are conditional upon the gas temperatures, and are, therefore, largely influenced by the method of operating the producer. Good practice has established for soot losses a range of from 3.5 to 4.5 per cent. of the total carbon in the coal.

The loss due to carbon in the ash should never be much greater than 1 per cent. of the total carbon in the coal. A clearer conception of the losses due to the presence of carbon in the ash and soot will be had if reduced to percentages of the total coal charged. The quantity of gas in cubic feet as measured by the meter under test conditions should be corrected for standard conditions; namely, the gas volume at 30 in. of mercury and 62 deg. F.; the absolute temperature of the gas at standard conditions, 522 deg. F.; and a standard pressure of 30 in. of mercury. The following formula will give corrected figures for the gas volume:

$$V_1 = \frac{T_1}{T} \times \frac{p}{p_1} \times V$$

where

V_1 = Gas volume at standard conditions (30 in. of mercury and 62 deg. F.);

T_1 = Absolute temperature of gas at standard conditions (522 deg. F.);

T = Absolute temperature of gas at meter conditions;

p = Pressure at meter conditions;

p_1 = Standard pressure (30 in. of mercury);

V = Gas volume at meter conditions.

The corrected pressure may be obtained by the following:

$$P = P_1 - P_2 - t$$

where

P = Corrected pressure;

P_1 = Barometric reading in inches of mercury;

P_2 = Manometer reading in inches of mercury;

t = Vapor tension reading in inches of mercury.

PRODUCER EFFICIENCY

From the various data obtained during the test it is a comparatively simple matter to determine the efficiency of the producer. The calculation is, of course, made on the unit basis of the gasification of 1 lb. of coal. Furthermore, there are two efficiencies to consider, the cold-gas efficiency and the hot-gas efficiency. The only difference between these is that the former does not take into account the sensible heat of the gas, whereas the latter does, making the hot-gas efficiency higher.

To determine the cold-gas efficiency the producer is first credited with the total B.t.u. per pound of coal charged. To this must be added the B.t.u. in the coal consumed in generating sufficient steam to gasify 1 lb. of coal. Also, if the producer tested is mechanically operated, the heat units in the coal required for its mechanical operation must be added. This sum divided into the product of the number of cubic feet of gas generated per pound of coal by the number of heat units per cubic foot of gas and then multiplied by 100 equals the cold-gas efficiency. Expressed as a formula, this calculation is as follows:

$$\frac{V \times h}{H_1 + H_2 + H_3} \times 100 = \textit{efficiency in per cent.}$$

where

V = Cubic feet of gas generated per pound of coal;
h = B.t.u. per cubic foot of gas;
H_1 = B.t.u. per pound of coal charged;
H_2 = B.t.u. in coal for generating steam to gasify 1 lb. of coal;
H_3 = B.t.u. in coal required for mechanical operation of producer.

The hot-gas efficiency may be represented by the formula:

$$\frac{V \times (h + h_1)}{H_1 + H_2 + H_3} \times 100 = \textit{efficiency in per cent.}$$

where h_1 is the sensible heat of the gas.

As a rule, it is hardly fair to charge the producer with steam used for blowing at 100 per cent. quality because it usually contains some moisture. This moisture is precipitated to a large extent in the injector and, therefore, does not enter the producer. Furthermore, this moisture may be due to condensation resulting from the relative locations of the producer and boilers and consequently is wholly independent of the former.

The amount of carbon gasified is equal to the total carbon in the coal minus the sum of the carbon in the ashes and soot. It is also evident that the total heat units in the coal minus the total heat units in the gas, ashes and soot will determine the heat losses due to radiation, etc.

⁂ ⁂

Starting and Stopping an Absorption Refrigeration Plant

By R. F. Proffitt

SYNOPSIS—An article for engineers not familiar with the system. Tells how to start and stop the plant and gives hints on purging and care.

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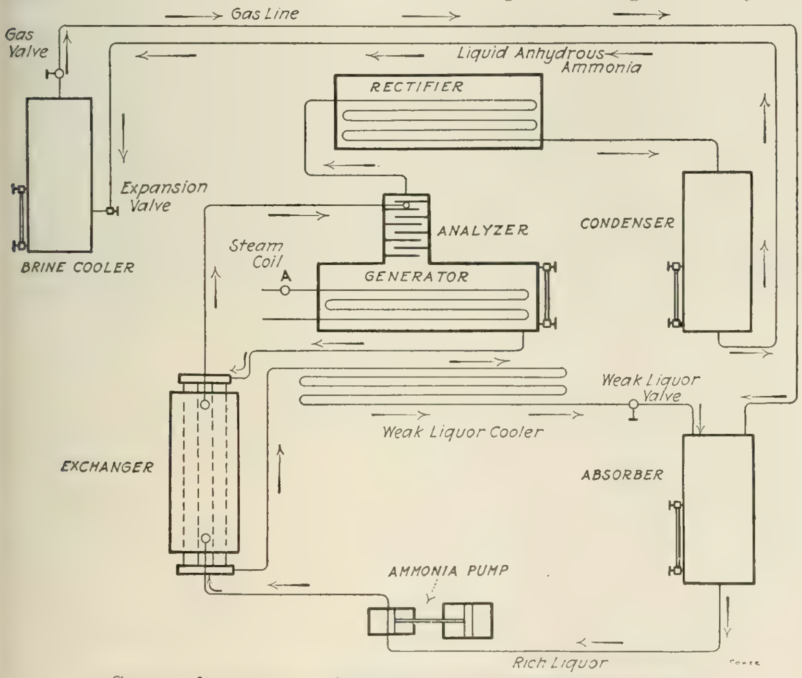
How the Absorption System Works

This article is intended for beginners. So as not to confuse the reader, the writer has left out of the diagram the water connections and valves not needed for starting and stopping the machine. It must be understood that the cooling water is a most essential part of this as of other refrigerating systems. Cooling water flows either through or over coils, in the condenser, absorber, rectifier and weak-liquor cooler. The system is charged with a mixture of water and anhydrous ammonia which is contained in the generator or still. Steam is circulated through the coils submerged in the aqua ammonia to heat the latter until the ammonia gas is driven off through the analyzer to the rectifier and into the condenser at a pressure corresponding to its temperature. In going through the analyzer most of the entrained moisture is separated from the gas by the baffles shown in the diagram. If there is any moisture left, it is picked up by the rectifier and returned to the generator. The rectifier partly cools the gas before delivering it to the condenser where it is condensed and becomes liquid anhydrous, which falls to the bottom of the condenser, and is then ready to be expanded in the brine cooler. It is admitted to the brine cooler through the expansion valve. After passing the valve it enters the cooler and the pressure is released as it is now expanding in a large space, absorbing heat from the brine which it cools. This process completes the operation of refrigeration, but the original conditions must be duplicated so that the operation may begin again. We now have the expanded ammonia at a very low pressure, and this must be returned to the generator again. To do this we have to use the ammonia pump and the absorber. By admitting the water or weak liquor that is left in the generator into the absorber, together with the gas from the cooler, the weak liquor absorbs the gas; hence the name absorber. As the weak liquor is at a high



Simple Diagram of Absorption Refrigeration System temperature it is cooled first before entering the absorber; it is cooled still more by contact with water-cooled coils in the absorber. It is now in its original state. The weak liquor is comparatively cool, however, so it is pumped through the exchanger where it meets the hot, weak liquor coming from the generator. The two liquids travel in opposite directions, the weak liquor entering at the top and passing out at the bottom, and the strong liquor entering at the bottom and passing out at the top. The strong liquor now enters the generator; the weak liquor is cooled more by going through the weak liquor cooler before entering the absorber as can be seen by the diagram. This completes the cycle of operation, and this process is continued until the brine is cooled. The brine is circulated through the ice boxes or tanks to be cooled as long as required.

STARTING THE SYSTEM

In starting the system, turn on all the water valves and be sure that the water is circulating properly. Open the steam valve A. Next open the weak-liquor valve about one turn. Start the ammonia pump slowly by opening the throttle valve. There is a governor on the pump steam line to control the speed of the pump so as to maintain a certain level of liquid in the absorber. It is best to operate the pump by the throttle valve until the system has reached its proper working condition so as not to lose the pump suction when the gas valve is opened, which is done after the ammonia pump is started. Open the gas valve slowly until wide open. Next, crack the expansion valve. This valve should be opened just enough so that by listening with your ear close to the valve you can hear the liquid going through with a slight singing noise but steadily, and so that a constant level is maintained in the gage-glass of the receiver. Enough steam should be admitted to the generator to bring the pressure up to about 180 lb. on the generator gage, but no higher. The pressure may be less according to the conditions, and can only be found by experiment. The pressure is governed by the amount of steam, the temperature and the amount of cooling water on the condenser.

SHUTTING DOWN THE SYSTEM

In shutting down, first close the expansion valve. Shut the steam valve on the generator, and allow a short time to elapse for the absorber pressure to drop to about one-third normal to allow the gas, still in the cooler, to get over to the absorber; then close the gas valve. Shut down the ammonia pump and wait a while to let the absorber liquid level rise a few inches to give a supply for starting up again. Close the weak-liquor valve and then shut all the water valves. Always bear in mind that the water is turned on first in starting up, and shut off last in stopping. The engineer should make a study of ammonia, and find out what it is composed of, and what it will do under different conditions, what gases it will form when mixed with air and oils and other foreign matter, as he will know then what is the trouble with the system when it does not work properly. Foreign or permanent gases will form in the system and should be purged off as soon as they appear.

PURGING THE SYSTEM

Purging valves will be found at the top of the absorber, brine cooler and the condenser. These gases, if left in the system, impair the efficiency of the machine and should be purged off as soon as possible. Purging into a pail of water is the best way, as you can then tell when the foreign gases are all gone. Purge slowly, and as long as bubbles appear on the top of the water, continue even if there is a slight odor of ammonia. There is no serious loss, as the ammonia that comes over with the foreign gas is of no use to the system as it will not condense. Foreign gases are usually lighter than pure ammonia gas. The writer worked with an engineer who did not believe in purging as he thought he would lose much anhydrous ammonia by doing so. The plant had not been purged in three years and the result was that in summer when he needed most work out of the system it would not work at rated capacity. He blamed it on the machine not being large enough to meet the conditions, and yet experts had allowed a large surplus for increasing load. In another plant there was a 12-ton system and the engineer purged frequently and was getting 20 tons out of it easily. There is nothing about this system to bother one if one will study the system under different conditions and experiment at odd times by making different adjustments of valves.

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Porous Brasses

Capt. F. W. Bartlett, in the February *Journal* of the American Society of Naval Engineers, tells how porous brasses were treated on the main engine shafts of the armored cruiser "Montana."

Although the brasses were inspected and tested under pressure at the time of fitting, when in service they permitted water to leak through and mingle with the oil to a slight extent. An examination showed the babbitt to be in excellent condition. The moisture apparently crept through small crevices to points under the babbitt, thence to the edges and slowly exuded from under it. In some instances, small drops appeared where there was no babbitt.

METHOD USED

The brasses were first filled with gasoline and subjected to a pressure of about 20 lb. and left in this condition for 12 hr., the object being to thoroughly cleanse the crevices of oil and water. As was expected, the gasoline slowly worked through.

The gasoline was then removed and air blown through for about four hours, after which the brasses were filled with shellac and kept under 75 lb. air pressure for another four hours, the intention being that the shellac would not set materially in that time. The alcohol in the shellac seemed to push ahead of it small particles of water or gasoline, and appeared as drops at the crevices. In some cases, the shellac could be seen to have passed through these crevices and to have deposited on the outside as a brown liquid. This soon congealed and no further leaks took place. The shellac was then removed from the surfaces, and air blown through the brasses for two or three hours with the idea of setting that remaining in the pores.

Upon testing the brasses for an hour with water at a pressure of approximately 75 lb., there was no sign of leakage, showing conclusively that the pores had been filled.

Warren Manufacturing Company's Plant

By Warren O. Rogers

SYNOPSIS—Some features found in a cotton-mill power plant. Low flue-gas temperatures due to the method of baffling the boilers. Superheated steam from two boilers mingles with saturated steam from nine others, superheating the steam in the main between 20 and 25 deg. This results in but little condensation in the steam lines, the longest of which is 600 feet.

*

Combining saturated steam and steam superheated 125 deg. in the steam mains leading to the engine units is the novel practice followed in the power plant of the Warren Manufacturing Company's cotton mill at Warren, R. I.

In 1889 this company had the distinction of operating a 2000-hp. quadruple, cross-compound condensing engine.* Later on, the mill and engine were destroyed by fire. When the new mill was built a 32½ and 68½ by 60-in. vertical cross-compound engine was installed which is now in operation. It develops 2500 hp. at 76 r.p.m. A feature in its piping is interesting in that it is so arranged that the engine can be started by either cylinder. Steam from the main header enters through a 12-in. pipe to a separator, which is piped to the high-pressure cylinder.

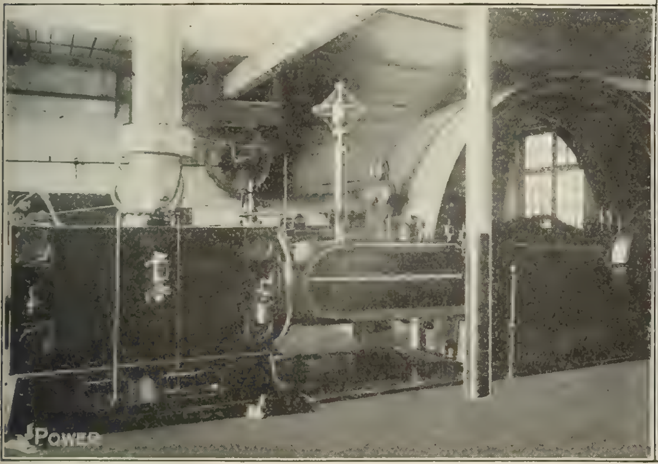

Fig. 1. One-Thousand Horsepower Cross-Compound Corliss Engine

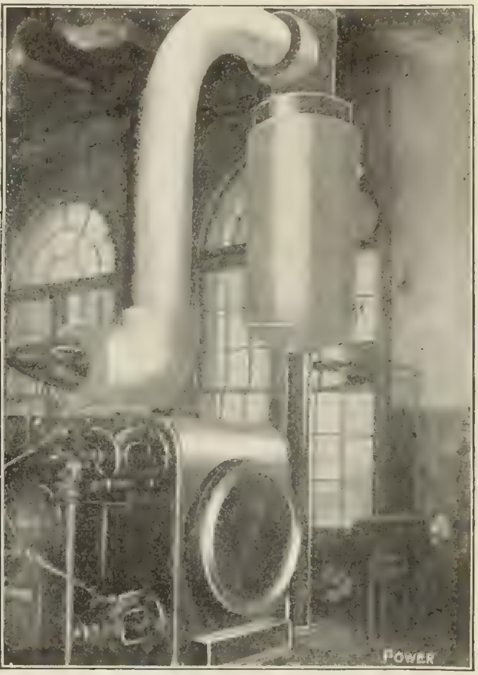

Fig. 2. Separator at End of 600-Ft. Pipe Line and Idle Steam Trap

Between the throttle valve and the separator a 12-in. pipe branches out and is connected to the 14-in. exhaust pipe between the receiver and a valve placed close to the exhaust side of the high-pressure cylinder. At the other end of the receiver a 14-in. pipe is connected to the low-pressure cylinder with a valve between the two. The 24-in. low-pressure exhaust is fitted with a valve between the cylinder and branches in the pipe, one of which leads vertically to the atmosphere and is fitted with a back-pressure valve, while the other connects to a horizontal feed-water heater, which is between the cylinder and the jet condenser. From the bottom of the receiver, which is at the rear and between the high- and low-pressure cylinders, a 14-in. pipe connects to the low-pressure exhaust line between the valve and the point where the branch occurs.

In case either cylinder or side of the engine is disabled, the other side can be operated as a simple engine and run either condensing or noncondensing. For instance, if the high-pressure side is disabled, it is only necessary to close the valve on both sides and admit steam to the receiver though the valve in the 12-in. bypass.

If the low-pressure side is out of order, the valve between the receiver and the cylinder is closed, and the valve in the exhaust pipe and that in the 12-in. low-pressure bypass opened. The high-pressure cylinder then exhausts in the regular way to the receiver, through the bypass and either to the atmosphere or to the condenser.

The feed-water heater raises the temperature of the feed water to 90 deg. and is forced by power pumps through the economizer, where the temperature is increased but 95 deg.; the reason will be explained further on.

When additions to the mill were made, the vertical engine became overloaded, and a second cross-compound horizontal unit of 1000 hp. capacity at 102 r.p.m. was installed, Fig. 1, having 18 and 36 by 18-in. cylinders. This engine also exhausts to a jet condenser, but is not connected to a heater. Both of these engines are close to the boiler room, and therefore no great amount of condensation would be expected, even with saturated steam.

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*"Power," June, 1889.

A still further extension of the mill necessitated another engine being installed 600 ft. from the boiler room. It is a horizontal cross-compound, of 1500 hp., running at 100 r.p.m., with 20 and 12 by 18-in. cylinders. The 7-in. steam main is suspended from beams in a storehouse by rod hangers with a bolt through the bottom of each, and on which a roller is hung, thus giving the pipe free movement.

It is in this pipe line that the benefit of the superheated steam is evidenced. In the engine room the pipe connects with a separator, the drip of which leads to a tilting trap, Fig. 2. During the writer's visit in the engine room the trap failed to discharge. When the cock on the top was opened it showed no water; dry steam only escaped.

The chief engineer and master mechanic, E. W. Trip, stated that after the engine is shut down, at least four hours elapses before the trap will tilt to discharge water of condensation. The dryness of the steam is attributed to the 25 deg. of superheat in the steam at the engine.

Boilers

There are two boiler rooms, which are separated by an economizer. In one there are two Heine water-tube boilers of 250-hp. rated capacity, equipped with superheaters which superheat the steam 125 deg. F. In the other boiler room there are nine 250-hp. boilers of the same make, but they do not have superheaters. These boilers are piped to the main header, where the saturated and superheated steam mingles and is carried to the several engines superheated at about 25 deg., at 150 lb. pressure.

The two boilers are operated under natural draft, but the nine boilers are worked with forced draft. The engine-driven blower is supported by a frame of I-beams at one end, and cross stringers; the outer ends of the stringers are supported by the boiler-room wall.

Fig. 3 shows the large battery of boilers. The discharge of the forced-draft fan is shown at the right. This air duct enters a square air main, 18x32 in. in size and which runs parallel with the boiler points. A 15-in. air pipe branches out of the main duct opposite each boiler and extends below the floor, where it turns at right angles and extends to the ashpit of the boiler to which it is to supply air. A maximum draft of 1 in. of water is automatically maintained when needed, the fan engine being equipped with a regulating valve.

The smoke flue for these boilers is 4½ ft. in diameter at the far end and increased gradually in size to 8 ft. where it connects with the economizer. Both sets of boilers are arranged to bypass the stack gases past the economizer by means of a series of dampers.

The chimney gases enter the economizer at a temperature of between 350 and 450 deg., according to the load on the boilers, and enter the 178-ft. chimney at 205 deg. The chimney is 13 ft. inside diameter at the top. The feed water is heated from 90 deg., at which temperature it leaves the heater, to 185 deg. upon leaving the economizer. This slight increase in temperature is due, of course, to the low temperature of the flue gases, which is the result of the manner of arranging the boiler baffling.

The idea is simple, that of removing the last row of brick from the lower baffle at the back end of the tubes, and the addition of one length of bricks to the top baffle at the front end of the tubes. This enlarges the area of the opening to the first pass of tubes and restricts the area from the other end. The result is that exceptionally good combustion occurs in the furnace and combustion chamber.

Looking into the rear end of the boiler furnace shows this to be so, as there is but slight indication of smoke and the temperature of the flue gases indicates that the boiler-heating surface is absorbing a high percentage of the heat. It is explained by the engineers that restricting the free escape of the heated gases gives them an opportunity to ignite before the temperature is lowered by coming in contact with the comparatively cold surface of the boiler tubes.

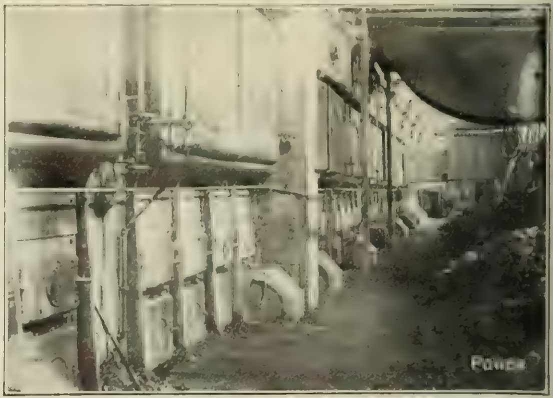

FIG. 3. BOILER ROOM CONTAINING NINE WATER-TUBE BOILERS. THE FORCED-DRAFT FAN IS SUPPORTED ABOVE THE FIRING AISLE ON GIRDERS

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Only 8 Per Cent. of Graduating Engineers Enter Other Fields—The statement that graduates of engineering schools do not follow the engineering profession is shown to be erroneous in the case of the College of Engineering of the University of Illinois. Data recently collected show that of the 2165 graduates, 1933, or 89 per cent., are engaged in one way or another in engineering work, and that only 173, or about 8 per cent., have gone into other fields. The occupations of the graduates of the College of Engineering are tabulated as follows:

	No.	Percentage
A—Nonengineering:		
1 Farmers and ranchmen	52	2.39
2 Merchants	31	1.42
3 Executive officers of mercantile companies	19	0.88
4 Editors	19	0.88
5 Real estate and insurance	15	0.68
6 Salesmen	10	0.46
7 Army officers	8	0.36
8 Bankers	6	0.28
9 Physicians	5	0.24
10 Lawyers	5	0.24
11 Miscellaneous	3	0.13
Total	173	7.96
B—Engineering:		
1 Employees of engineering companies	1370	63.2
2 Architects	318	14.6
3 Executive officers of engineering companies	130	6
4 Teachers	95	4.6
5 Consulting engineers	20	0.92
Total	1933	89.32
Deceased	59	2.72
Grand total	2165	100.00

Fixing the Decimal Point in Slide-Rule Calculations*

By Charles G. Richardson

Not long ago the slide rule was frequently held up to ridicule, especially by those who could not or would not use it. It was termed a "guess-stick," and an error by the manipulator was hailed with satisfaction. This feeling now has given place to one of respect for its value as a great time and energy saver in mechanical calculations, but the idea seems to prevail that to acquire skill with the rule one needs unusual mental equipment. In the writer's opinion, the inexcusably opaque "instruction" books which have been distributed with slide rules are in a great measure responsible for these conditions. Another feature of the slide rule which has discouraged beginners and generally limited its use is the determination of the position of the decimal point. Some eight years ago the writer devised a method of locating the decimal point in slide-rule calculations which is extremely simple and which can be applied to any combinations of multiplication and division. Bearing in mind that when the words "left-hand figures" are used *the number of figures to the left of the decimal point* (or in the integral portion of the number) is meant, there are two short rules which must be thoroughly memorized as follows:

Rule No. 1. Multiplication—The left-hand figures in the product equal the sum of the left-hand figures in the factors, except that one left-hand figure must be subtracted for each time the slide projects to the right.

Rule No. 2. Division—The left-hand figures in the quotient equal the left-hand figures in the dividend minus the left-hand figures in the divisor, except that one left-hand figure must be added to those in the dividend for each time the slide projects to the right.

These two rules embody the whole method, and once having been learned there only remains their application. *Note that no reference is made to slide projections to the left.*

The number of "left-hand figures" would be

3 in 954.210
2 in 53.198
1 in 5.733
0 in 0.534
—1 in 0.014
—2 in 0.004

The use of the two rules will now be illustrated by examples chosen at random, leading from simple problems to those more complex. The calculations are given in detail, but after a little practice the decimal point can be determined mentally with rapidity. It is understood that the lower scales C and D on the rule are used.

Example:

$$7 \times 5 = 35$$

The slide does not project to the right; therefore add the left-hand figures of the factors, giving two in the product.

Example:

$$8.5 \times 6 \times 12 = 612$$

The slide projects once to the right; therefore add left-hand figures of factors and subtract 1, giving three units in the product.

Example:

$$8 \times 6 \times 12 \times 0.13 \times 0.075 = 5.62$$

The slide projects twice to the right; therefore $(1 + 1 + 2 + 0 - 1) - 2 = 1$ left-hand figure in the product.

Example:

$$\tfrac{150}{25} = 6$$

The slide does not project to the right; therefore subtract the divisor's left-hand figures from the dividend's, or $3 - 2 = 1$ figure in the quotient.

Example:

$$\tfrac{380}{25} = 15.2$$

The slide projects once to the right; therefore add 1 to the dividend's left-hand figures and then subtract the divisor's, or $(3 + 1) - 2 = 2$ left-hand figures in the quotient.

Example:

$$\frac{4800}{24 \times 16} = 12.5$$

The slide projects twice to the right; therefore $(4 + 2) - (2 + 2) = 2$ left-hand figures in the quotient.

In formulas involving a combination of multiplication and division the value of the method especially asserts itself. For instance, the slide-rule lesson in the Study Course (Feb. 10, p. 211) gives the following example:

$$\frac{605 \times 921}{437} = 1275$$

First dividing, then multiplying, gives one projection of the slide to the right in division, or adding one to the dividend's left-hand figures and subtracting the divisor's we obtain $(3 + 3 + 1) - 3 = 4$ left-hand figures in the result. The Course states that it is clear that the answer "is a whole number and there is no decimal point to be placed." It seems to the writer, however, that it is not at all clear *how many* places there are in the whole number as compared with the simple method of locating the decimal point just described.

When a projection to the right in division is followed by a projection to the right in multiplication, the corrections balance each other since the former adds one and the latter subtracts one from the left-hand figures in the dividend, and hence both may be disregarded. For instance, another Study Course problem (Feb. 24, p. 283) is

$$\frac{0.492 \times 1.29}{33.4} = 0.019$$

in which the author, after performing the slide-rule manipulations, says, "Now to locate the decimal point. Inspection of the numerator shows it to be approximately 0.5 and 33 will not go into it until it is multiplied by 100 or the decimal point moved two places to the right. The first figure in the answer will, therefore, come in the second place after the decimal point, or 0.019 is the answer." How much simpler to observe that the slide projects to the right once in division and once in multiplication forming a balance, or $(0 + 1) - 2 = -1$; or there is a cipher before the first figure in the answer.

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*See also "To Find the Number of Integer Places in a Product or Quotient," "Power," Mar. 24, 1914, page 400.

Example:

$$\frac{17 \times 11 \times 24}{32 \times 68 \times 0.81} = 3.24$$

Here we have one projection to the right in multiplication but none in division, and consequently (2 + 2 + 2 − 1) − (2 + 2 + 0) = 1 left-hand figure in the result.

As we proceed to longer examples it may be difficult to separate *mentally* the number of projections to the right in multiplication from those in division. Short vertical lines may be used to keep this score, these marks being placed either above or below the division line, depending upon whether the operation is one of multiplication or of division. When a projection to the right in division is immediately balanced by a projection to the right in multiplication by moving the runner to the next number in the dividend, no score is necessary. To illustrate:

$$\text{Score} \quad \frac{118 \times 230 \times 1.96 \times 0.00062 \times 186}{191 \times 0.063 \times 68 \times 0.13 \times 15 \times 12.5} = 0.302$$

Taking the solution step by step:

118 ÷ 191	slide is to left (disregard)
Multiply by 230	slide is to left (disregard)
Divide by 0.063	slide is to left (disregard)
Multiply by 1.96	slide is to right (score above line)
Divide by 68	slide is to left (disregard)
Multiply by 0.00062	slide is to left (disregard)
Divide by 0.13	slide is to right (balance—disregard)
Multiply by 186	slide is to right
Divide by 15	slide is to right (score below line)
Divide by 12.5	slide is to right (score below line)

Now the excess of the lower score over the upper is 1; therefore the slide has gone once more to the right in division than in multiplication; hence 1 is to be added to the dividend's left-hand figures before subtracting the divisor's. It makes no difference in what order the problem is solved, the *excess* of one group of projections to the right over the other group will be the same.

Eight years of daily use of the method in a department requiring calculations of considerable complexity has thoroughly demonstrated its value in promoting accuracy and rapidity.

* *

Central Stations and Independent Plants

By W. H. Booth

There are places where it is cheaper to buy current from some central station than it is to make it for oneself. A central-station man is usually adept at showing that private plants are costing much more to their owners than purchased current, but there is no good reason why a private plant should be so much less economical to work. Each case must be taken upon its merits and only general views can be taken in a discussion. In favor of the central station it is usual to claim that fuel, stores, oil, etc., can be bought for minimum prices and that wages are less per unit of current. When a central-station man compares costs he includes on both sides the capital cost of the space occupied and the proper share of the wages to be debited against current. Now good and particular accounting is all very well in its proper place, but this sort of accounting is often merely of an academic character and if carried too far may result in loss.

In the erection of buildings certain foundations are necessary and these result in basements and sub-basements which involve capital cost and are not available for the uses to which daylight floors may be put. This capital cost being an essential part of a building and not having a letting value, or a use value other than for a power plant, is not properly chargeable against the cost of current. For, if by adding this charge, the owner is made to appear to be a gainer by the purchase of outside current, he will still remain liable to pay the interest on the capital expended on the useless part of the building. Again, if he must install steam heat and therefore pay for boilers, the cost of such boilers can only be debited against current in so far as it has been made greater for the sake of higher pressure for engine working. And if fuel must be used for the steam heating and this heating happens to use all the exhaust steam from the power plant, can it be fair to charge the power plant with more of the fuel cost than is represented by the small fraction of the heat converted into work and that lost by radiation from the power plant? And so with labor costs. If there must be a staff of two men without a power plant, and the same two men can do the work with the power plant, this charge cannot be debited to current when it becomes a question of deciding on the true cost. In short, the accounting for this purpose must show simply how much more or less the owner will pay on the whole building, plant and men and materials when he has and when he has not a power plant installed.

In a private plant all turns on the man in charge. A good man will run a so called obsolete plant with better results than the central station will sometimes get out of the so called best plant. One hears and reads much today about top-notch plants and efficiency. But the high records of top-notch plants are obtained very much by engineering accounting on the lines above indicated. An engine is using so much steam per horsepower-hour, as shown by the Lea recorder, but this instrument is not meant to be used other than its location warrants. It does not show heat losses in steam pipes, or at the boilers. It is possible, with a small staff, to run a low-pressure plant in good order and to save money as compared with the overall costs of a top-notch plant.

In England it is certainly a fact that the methods of charging for current have been developed on the academical view of what a user should pay. The utmost indignation is felt at the idea that a small consumer should use what he does use during one hour only per day. It is pointed out how to supply him with that one unit-hour. there is $100 of plant at the station and that he uses it only one hour out of 24. Before he can be supplied he must pay interest on the 23 hr. This righteous and furious attitude is adopted toward any number of small users, the while papers are being read on diversity factors and all manner of other academic matters. The charging faddists have rendered any attempt at a diversity factor impossible. Because one man uses current only from 9 to 10 a.m. all other small users apparently use current only from 9 to 10 a.m.

The attitude of the electrical supplymen has been one of antagonism to the user, based on the difficulty of economical storage of electricity. The central-station man adopts a similar attitude toward the private plant. There is, of course, a limit below which a plant may be more costly than to purchase current. It would often be so in this country but for the systems of charging. Thus current is sold for 2c. per unit. This sounds very nice, but it is loaded up with an unwarrantable charge per quarter upon each rated horsepower of the motor. Thus, if to be liberal, a 5-hp. motor be put in to drive a 1½-hp. water pump, which will not take 3 hp. of current, the motor will be taxed nearly $10 per quarter and the cost of current runs up to many times 2c. per unit.

Where uncontrolled by an engineer, contractors are apt to put in excessive motors, and so it comes that power users are actually taxed on a few figures stamped on a nameplate. This is particularly unfair with a well-pump motor, for the work always remains constant and the maximum and excess power of the motor is never used.

All this is excellent as a means of squeezing dollars out of a user of current, but it is not good business and is only a way of making known as one client put it, that "the supply company will have you anyhow" and so he insisted on steam power.

Private water-supply systems are used very much in London, because the charge for public water is made 5 per cent. on the rental value of the building. Now a large building, housing at most, say, 500 or 1000 people, will only consume a few thousand gallons of water per day. By meter such would cost $1 down to 75c. per day or less, but on the assessed value the water charge may be $4 upward per day. A private supply may cost 30c. per day in interest and from nothing to 4c. per 1000 gal. to pump. With electric power, which is the nicest drive, the pump runs only when the water level drops a certain distance in the roof tank and it then runs until the tank fills—all according to the setting of the automatic switch and float. The taxes on motor rating compel or induce owners to consider steam power, drives off the hydraulic-pressure mains or gas power, none of which are so simple or occupy less space than the electric drive with a worm gear direct on the pump shaft.

Were the nation as a whole efficiently organized for economy it would not be possible that such a state of affairs could prevail. There is first the tussle between the public supply of water and the owners' right to tap the deep, pure water under his feet. Next there are the several systems of driving the pump and for every case he meets a contractor is apt to push one more than another irrespective of conditions. Out of five taken at random, two are electrical, one is gas driven, one steam driven and one has a 33-lb. natural-pressure head and needs no pumping. In each case the best has been done for the given conditions.

Nobody can declare offhand as a general proposition for or against independent supply of water or electricity. And in no case can the question be decided by what some men call a fair and proper allocation of costs. Practical men know this.

I once knew a man who had a good business which was departmentalized. In addition to selling departmental products there was a department for assembling parts and selling a finished product. To this department all material was charged at full profit rates and at the end of the year this department showed a small profit on its turnover. It had, however, enabled the other departments to sell parts at a profit and it had done its share in paying overhead charges. It was, in short, producing a profit inside the four walls. The owner shut it down as a loss. He was a victim of academic accounting.

Power Plant of the Boston Opera House

SYNOPSIS—An isolated plant with marine water-tube boilers and direct-connected generator and engine units. Special attention having been given to preventing vibration, it was eliminated by insulating the foundations from the building proper.

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The disagreeable feature of vibration is manifest in many buildings where no attempt has been made to prevent it. Although the engines may be in the basement, far from the tenants, all feel the vibration of the engines more or less. This disagreeable feature is avoidable in most cases with but little additional expense, and attention to it will result to the satisfaction of all.

In the case of a place of amusement, one can easily

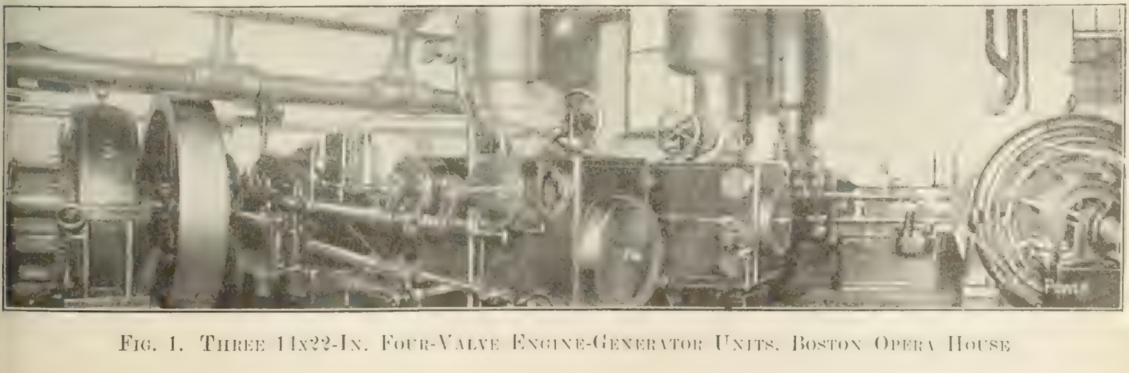

Fig. 1. Three 14x22-In. Four-Valve Engine-Generator Units, Boston Opera House

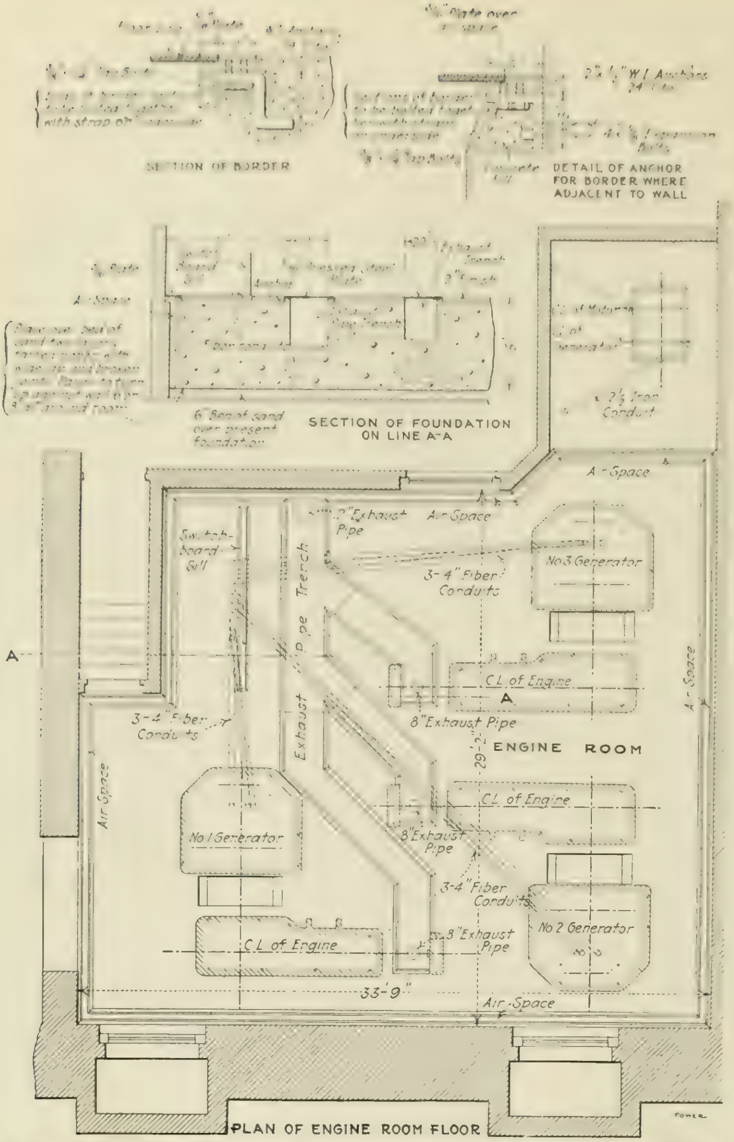

Fig. 2. Details of Engine Foundation at the Boston Opera House

realize the annoyance caused by the constant jars of vibration sent to every part of the house, both to the audience and to the performers. When the Boston Opera House was built, this discordant feature was given consideration. The engine foundations are separated from every part of the building by air spaces, thus vibration has been eliminated.

In the engine room there are three 14x22-in. Ball four-valve engines, directly connected to three Westinghouse 125-kw., 125-volt generators, at 200 r.p.m., Fig. 1. These units have separate foundations constructed as shown in Fig. 2. First spiles were driven and the spaces between them filled with concrete. On this a 6-in. layer of sand was placed, being covered by two layers of tarred paper with wide lap and broken joints. The paper is turned up against the wall about 7 in. all around the room; on this the concrete foundations rest. They are 5 ft. thick and are provided with trenches for the exhaust pipe and conduits for the generator cables running to the switchboard. A 4-in. air space is provided between the foundation and the walls of the building.

The engine-room walls are built with a shelf to which 2x½ in. wrought-iron angles are secured by 4x⅝-in. expansion bolts. On the foundation side, angle irons are imbedded in the concrete, and metal-border strips rest on the two sets of irons, coming a little below the level of the floor. The ⅝-in. pressed-steel floor plates over the air spaces are fitted to the side strips, which are planed to such a depth that the plates come even with the engine-room floor.

In addition to the main generating units, there is a 25-kw., motor-driven, 125-volt generating set for use when all of the engine-driven sets are idle. Central-station current is used on this unit.

The main steam header is 10 in. in diameter and is supported by vertical pipe stands imbedded in the foundation. On the top end is a roller to allow for the movement of the pipe line. By this arrangement the header is not attached to any part of the building and there are no ill effects from vibration. A 6-in. lead branches from the top of the 10-in. header for each engine. The exhaust pipes run in a trough in the foundation to an open heater in the boiler room.

Steam is generated in two 250-hp. Worthington water-tube boilers. They are hand fired and carry a pressure of 125 lb.

Boiler-feed water is obtained from either of two 7½ and 5 by 6-in. duplex pumps. There is also a vertical sump pump driven by a 1-hp. motor. It is automatic in action, the height

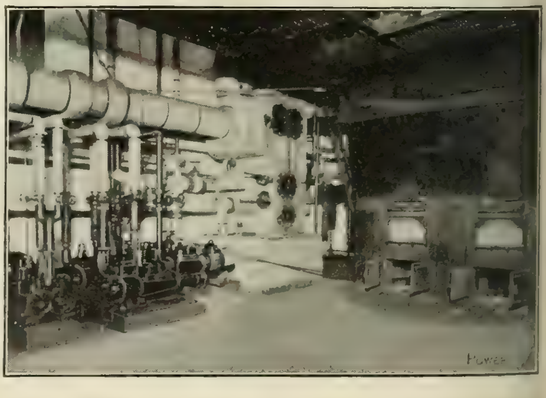

Fig. 3. One of the Boilers and the Steam Pumps

of water in the sump starting or stopping the motor by means of a float and a weighted double-throw switch. All of these pumps are in the boiler room. Attached to the wall is a vertical 9½ and 9½ by 10-in. air pump used for elevating the stage and operating the drip curtains.

Coal is delivered from wagons through a manhole to the hopper of a motor-driven belt conveyor and is discharged into a storage room adjoining the boiler room. It is wheeled in for use as desired. In the winter during cold snaps, when the coal is frozen, it is found advisable to break the lumps to prevent stoppage in the hopper.

⁂

Synchronous Converters and Their Operation—I

By Eric A. Lof*

SYNOPSIS—The general characteristics of synchronous rotary converters, the voltage and current ratios and methods of regulation. A second installment will cover their operation.

⁂

The synchronous converter is the most generally used machine for converting alternating into direct current, and *vice versa*. Mechanically, it is similar to a direct-current generator to which have been added collector rings and their connections to the armature winding. Electrically, however, it is quite different, and, although in its relation to the alternating-current supply it acts as a synchronous motor and to the direct-current circuit as a direct-current generator, it is essentially different from these machines so far as the armature reaction and heating effect of the armature currents are concerned.

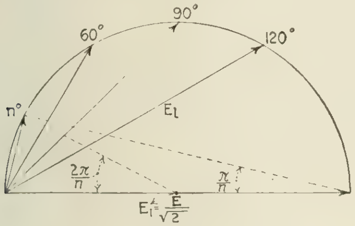

FIG. 1.

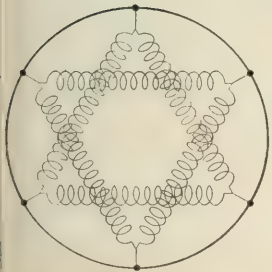

FIG. 2.

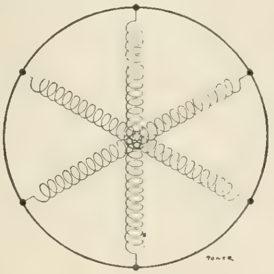

FIG. 3.

The torque produced by the alternating current, and consumed by the direct current, is applied at the same conductors; consequently there is no transfer of mechanical energy, and the machine structure can be made smaller than a direct-current generator of the same rating. The current actually flowing in the winding is made up of the difference in instantaneous values of the variable alternating current and the constant direct current. These partly neutralize each other and the current actually flowing is much less than would otherwise be the case, resulting in a reduced copper loss.

VOLTAGE RATIO

The theoretical voltage ratio of a converter is readily determined. In single-phase machines the two collector rings are connected to armature conductors with the same angular distance apart as the commutator bars under adjacent sets of brushes, and

$$E_1 = \frac{E}{\sqrt{2}}$$

where

E_1 = Effective value of the alternating e.m.f.;
E = Direct current e.m.f.

Representing the effective e.m.f. between the collector rings of a two-ring, single-phase converter by the diameter of the circle in Fig. 1, the effective e.m.f. E_1, between adjacent rings of a converter having n rings may be represented by that chord which subtends an angle of $\frac{360°}{n}$ or $\frac{2\pi}{n}$. That is,

$$E_1 = \frac{E}{\sqrt{2}} = sin \frac{180°}{n}$$

which gives:

For single phase

$$E_1 = \frac{E}{\sqrt{2}} = 0.707\,E$$

For three phase

$$E_1 = \frac{\sqrt{3}\,E}{2\,\sqrt{2}} = 0.612\,E$$

QUARTER-PHASE. This converter generally has each phase of the supply circuit connected to diametrically opposite points of the armature winding, and the ratio equals that of the two-ring single-phase converter, or

$$E_1 = \frac{E}{\sqrt{2}} = 0.707\,E$$

SIX-PHASE. Two different connections are used with this type, the "double-delta" and the "diametrical." With the former, Fig. 2, the voltage ratio is the same as for the three-phase converter, the connection simply consisting of two delta systems. With the diametrical connection, Fig. 3, the ratio is the same as for the single-phase converter, it being similar to three such systems. Therefore, for six-phase, double-delta.

$$E_1 = \frac{\sqrt{3}\,E}{2\,\sqrt{2}} = 0.612\,E$$

For six-phase, diametrical.

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*Electrical engineer, General Electric Co., Schenectady, N. Y.

$$E_1 = \frac{E}{\sqrt{2}} = 0.707\ E$$

With six-phase converters, the transformers can also be connected in "double star," in which case the ratio between the phase voltage and the direct voltage will be the same as for the "double delta" connection. The ratio of the effective e.m.f. E_n between any collector ring and the neutral point is always

$$E_n = \frac{E}{2\sqrt{2}} = 0.354\ E$$

The foregoing ratios are only theoretical, the actual values differing somewhat, depending upon: The wave shape of the impressed e.m.f., that is, the ratio of the potential, as read by a voltmeter, to the maximum instantaneous value of the wave; the construction of the machine, especially the ratio of the pole arc to the pole pitch; the resistance of the armature winding causing a drop of potential in the armature as well as in the brushes under load; the operating conditions, that is, the brush position, the field excitation and whether the converter is used to change from alternating to direct current or *vice versa.*

The direct e.m.f. bears a definite relation only to the maximum value of the alternating e.m.f. and to the effective value only insofar as the latter depends on the former. Therefore, with a flat-topped impressed e.m.f. wave, the maximum value and the direct e.m.f. depending thereupon, will be lower than with a sine wave of the same effective value, while with a peaked impressed wave they will be higher.

The ratio of pole arc to pole pitch is also an important factor influencing the voltage relation. By altering this ratio the curve of flux distribution is changed; hence also the ratio between the maximum and effective values of the induced alternating e.m.f.

When converting from alternating to direct current, the voltage at the commutator brushes is less than the generated direct e.m.f. and the counter generated alternating e.m.f. is less than the impressed, due to the resistance drop in the armature and brushes. The armature self-induction has little effect if the current is in phase with the impressed e.m.f. If the current is lagging, however, the counter generated alternating e.m.f. is reduced below the impressed and, if leading, it is increased. Thus the direct voltage will decrease with increased load and decreased excitation (lag), but increase with increased excitation (lead).

For inverted converters the alternating voltage is decreased with increased load, especially load of lagging current, and is increased with leading current. The excitation, however, has no direct effect on the ratio, but decreased excitation increases the speed and thus the frequency, and inversely, except when the frequency is fixed by parallel operation with an alternating-current system of fixed frequency. In the latter case, a change of excitation simply changes the current phase, and with it the ratio.

From the foregoing it follows that it is impossible to give a value for the actual voltage ratio which will apply to different types of converters. In general, however, the following values may be taken as approximately correct.

RATIO A. C. TO D. C. VOLTAGE

Phase Connection	No Load Cycles 25	No Load Cycles 60	Full Load Cycles 25	Full Load Cycles 60	Inverted Full Load Cycles 25	Inverted Full Load Cycles 60
Single-phase, quarter-phase and six-phase diametrical	0.71	0.72	0.72	0.73	0.69	0.70
Three-phase and six-phase double delta	0.61	0.62	0.62	0.63	0.60	0.61

VOLTAGE

The direct voltage generally used is 275 volts for power and lighting work, while for railway work, the standard voltage has been 600. During the past few years, however, a potential of 1200 volts has become a recognized standard for interurban lines, while 1500 volts is as yet more in the nature of a special voltage for those cases where the saving in copper offers sufficient advantage.

CURRENT RATIO

The ratio between the direct current I and the effective value of the alternating current I_1, entering at the collector rings, is subject to greater variation than the voltage ratio. This, however, is not of great importance from an operating standpoint, as it is only necessary to know the current ratios in connection with the armature heating, which determines the rating of the converter, and for this purpose an approximate value is sufficient.

Neglecting the losses in the machine, and assuming the impressed and induced alternating e.m.f. to be in phase, the output from the direct-current side must equal the input to the alternating-current side. Let

E = Direct e.m.f.;
E_1 = Effective value of alternating e.m.f.;
I = Direct current in line;
I_1 = Effective value of alternating current in line;
I_a = Effective value of alternating current in winding;
n = Number of rings.

For a single-phase converter

$$E_1\ I_1 = E\ I$$

but

$$E_1 = \frac{E}{\sqrt{2}}$$

whence

$$I_1 = \sqrt{2}\ I = 1.414\ I$$

In general for converter with n-rings

$$I_1 = \frac{2\sqrt{2}\ I}{n}$$

The current in the windings is obtained from the formula

$$I_a = \frac{\sqrt{2}\ I}{n\ \sin\frac{180°}{n}}$$

The following table shows the approximate current ratios in a convenient form:

APPROXIMATE CURRENT RATIOS, ALTERNATING TO DIRECT

Phase Connection	Effective Line Currents	Effective Currents in Winding
Single-phase	1.414	0.707
Three-phase	0.943	0.545
Quarter-phase	0.707	0.5
Six-phase	0.472	0.472

HEATING AND CAPACITY

The rating of a synchronous converter is generally determined by the heating and commutation. It can, as a rule, be comparatively expressed in terms of the rating which the same machine would have if operated as a direct-current generator. The following tabulation gives the output at unity power factor of different types of synchronous converters with the same heating that would take place if the converters were operated as direct-current generators, the losses being neglected for simplicity:

COMPARATIVE CAPACITIES OF SYNCHRONOUS CONVERTERS ON BASIS OF AVERAGE HEATING AT UNITY POWER FACTOR

Direct-current generator	100
Single-phase converter	85
Three-phase converter.	134
Quarter-phase converter	164
Six-phase converter....	196
Twelve-phase converter.	224

It is seen from the above that the more points at which the winding of a converter is tapped, the more direct is the path from the collector rings to the commutator, and the less is the heating of the armature conductors. These can, therefore, be of smaller cross-section than in a direct-current generator of the same capacity and, consequently, the greater the number of phases, the greater is the capacity of a synchronous converter as compared with a generator or motor. A considerable gain is made by changing from three-phase to six-phase, but relatively little economy is obtained by still further increasing the number of phases.

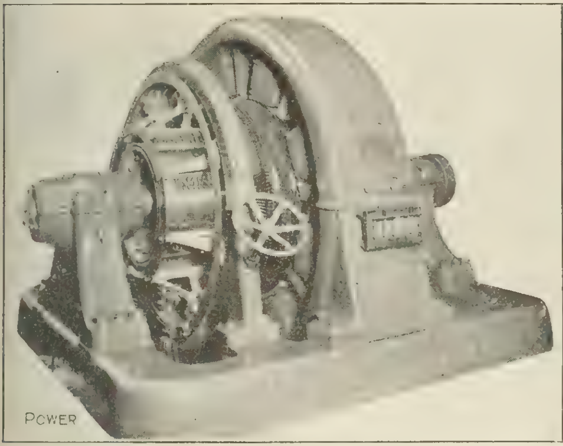

Fig. 4. Regulating-Pole Converter, 750-Kw., $^{240}/_{300}$ Volts

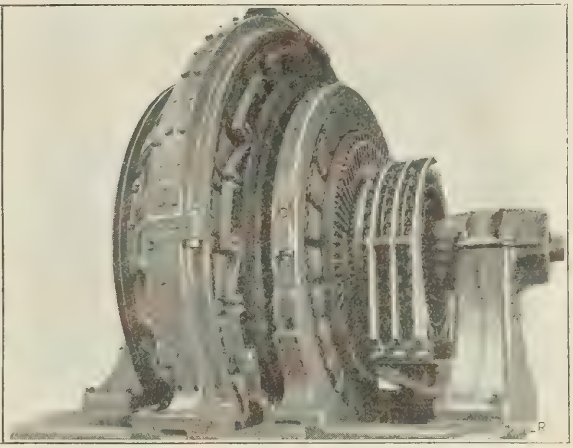

Fig. 5. Synchronous Booster-Converter, 3500-Kw., $^{240}/_{310}$ Volts

The standard temperature rise guarantees at the present time for sychronous converters, except for the smallest sizes, are 35 deg. C. (95 deg. F.) for continuous full load at unity power factor, and 55 deg. C. (132 deg. F.) for two hours, with 50 per cent. overload at unity power factor. Occasionally a 5-deg. higher temperature is allowed for the collector rings and the commutator. These guarantees are based on a room temperature of 25 deg. C. (77 deg. F.) and correction for differences therefrom are made in accordance with the rules of the American Institute of Electrical Engineers.

Converters are now built in sizes up to 2500 kw. for 60 cycles and 4000 kw. for 25 cycles.

Frequency

Twenty-five and 60 cycles are the two standard frequencies in this country, the former principally in connection with railway and power service and the latter for lighting. The converter being a synchronous machine, the frequency must have a fixed relation to the speed and the number of poles, from which it follows that the peripheral speed of the armature and commutator increases with the frequency. The peripheral speed of the commutator is limited both by mechanical and electrical considerations.

The present reliability of the 60-cycle converter is due principally to the improvements in mechanical design. With the ability to build longer high-speed commutators, it became possible to increase the speed and thus the output per pole. In recent machines the output per pole has been increased beyond the inherent commutating ability, and commutating poles have been adopted.

Voltage Variation

It is often necessary to vary the direct-current voltage over a considerable range. Such a variation, however, cannot be made by simply varying the field strength as in the ordinary direct-current generator. Therefore, it is necessary to provide means for changing the applied alternating voltage, which can be accomplished in a number of ways.

Transformer Taps: This method consists in the use of quick-acting switches connected to the taps of the transformers. Such a mechanism, however, is complicated and the arcing is apt to start short-circuits; hence it is seldom used.

Shunt-Wound Converter with Induction Regulator: A much better method is the use of an induction regulator between the terminals of the transformer secondary terminals and the synchronous converter. This avoids the necessity of any switching and gives a smooth variation in the supply voltage. The regulator consists of a movable primary winding, which is excited at constant alternating-current line voltage and induces practically constant voltage in the stationary secondary, connected in series with the line.* The voltage variation is obtained by turning the movable element through an angle, which changes the phase relation of the secondary voltage to the line voltage, to which it adds or subtracts vectorily. It is, therefore, possible to increase and decrease the line voltage by any amount up to the full secondary voltage of the regulator.

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*See "Power," Dec. 30, 1913.

This method of control is generally used with shunt-wound converters in order to keep the voltage constant, when the line drop is excessive. The induction regulator is either hand operated by means of a chain or motor drive, or the control can be made automatic by using a contact-making voltmeter and relay, which will automatically control the regulator motor.

Compound-Wound Converter with Reactance Coils: This method of voltage variation is based on the fact that an alternating current passing over an inductive circuit will decrease in potential if lagging, and increase if leading. As in the synchronous motor, a decrease in the field excitation will cause a synchronous converter to draw a lagging current from the line, and an increase in the field excitation a leading current. The total value of the current, however, will be increased, but the lagging and leading components do not represent any expenditure of energy, except that of the increased resistance loss in the conductors.

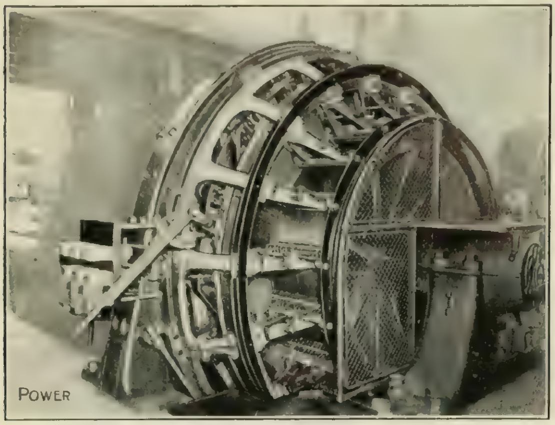

Fig. 6. 4000-Kw., 600-Volt, Commutating-Pole Rotary Converter

The excitation can be automatically regulated as the load comes on by providing the synchronous converter with a series field winding in addition to the shunt field. The inductance of the supply circuit and the step-down transformers, however, is frequently not sufficient to cause the required boost in the voltage, and in such a case it becomes necessary to insert reactance coils in the line or design the step-down transformers for extra high reactance. The lower the reactance, the greater must be the strength of the series field for the same regulation, and the larger is the lagging or leading current required. Inversely, too high reactance may lower the overload capacity of the converter. This method of voltage control is extensively used in railway work, where only a slight variation in the direct-current voltage is generally necessary.

Regulating-Pole Converters: This type offers a simple means of obtaining a variable direct-current voltage from a constant alternating-current voltage. It differs from a standard machine only in that the field structure is divided into two poles—a main pole and a small regulating pole. For normal voltage the main pole only is excited, while to raise or lower the direct voltage, the regulating pole is excited so as to either assist or oppose the effect of the main pole.

The regulating pole may be provided with either a shunt or a series field. When shunt wound, it may be controlled by a field rheostat either by hand or automatically, to hold a certain voltage or a certain load. Machines so equipped are particularly suited to constant-load service, but should not be used if required to carry light loads at the lower part of the voltage range, if they are to do so for periods much longer than is necessary for adjusting to the required voltage of the load before switching into service. At low voltage, the field for commutation is too strong for light loads, although excellent for heavier loads.

With series-wound regulating poles a great degree of overcompounding can be obtained with little change in the power factor. With the direction of rotation such that an armature conductor passes the regulating pole before the main pole, the machine will commutate almost the same as a commutating-pole machine.

Sometimes the regulating pole is provided with both a shunt and series winding. The former permits hand adjustment of the voltage for changes in service conditions.

Fig. 4 illustrates a synchronous converter of the regulating-pole type.

Series-Booster Converter: This consists of a standard synchronous converter and a series or booster alternating-current generator. The latter has the same number of poles as the converter, is mounted on the same shaft with it and is connected in series between the converter and the low-tension side of the transformers. There are two types of construction, the revolving-field type in which the booster is mounted on the outside of the collector end pillow block, and the revolving-armature type in which the booster is mounted between the collector rings and the armature winding of the converter, as shown in Fig. 5.

By varying or reversing the field excitation of this booster, the alternating voltage impressed on the converter proper can be increased or decreased as desired, the direct-current voltage delivered by the converter varying accordingly. By means of a reversing switch in the field circuit the polarity of the booster field may be reversed without opening the field circuit, and the generated voltage made either to "buck" or "boost" the voltage impressed at the collector rings.

Converters with Commutating Poles: The use of commutating poles on synchronous converters is comparatively new. With the addition of these poles the commutation may be so improved that the output per pole is nearly doubled. If the load is steady and uniform, it is evident that the limit of the design is caused by the heating. For fluctuating loads and with heavy overloads of short durations, such as in interurban-railway systems, steel mills, etc., the heating limit is eliminated. In other words, for the same kind of service, a smaller and lighter converter can be built, its rated load being correspondingly less and much nearer the average load.

The ampere-turns required by the commutating poles are much smaller than those required by a direct-current generator having an ordinary air gap. This is because the excitation of the commutating poles need only be sufficient to generate a counter e.m.f. equal to the reactive voltage caused by a reversal of the load current of the coil while passing under a brush. It is unnecessary to provide additional excitation to cancel the armature reaction as in the case of a direct-current generator. Any disturbance tending to unbalance the usual alternating and direct-current relations would produce an armature reaction which would be a large percentage of the total excitation of the commutating poles and thus greatly affect the commutation. To prevent this it is advisable to increase the required excitation, which is done by using larger air gaps. Even then the sparking, when started from the alternating side, is quite severe, but this is overcome by providing a brush-lifting device, as shown in Fig. 6.

Two narrow brushes, one for each polarity, however, are allowed to remain on the commutator when starting so as to provide current for field excitation and to indicate the polarity. The sparking caused by these two pilot brushes is harmless, as they are very narrow, thus short-circuiting at a much lower voltage than would the main brushes.

As with the direct-current commutating-pole generator, an inductive shunt is also used. Its inductance is greater than the commutating field so as to accomplish the changes in the field strength more quickly. A greater percentage of the current will pass through the commutating-pole winding for increasing loads than at steady load, and for decreasing loads the commutating-pole current will be less than with the corresponding armature current at steady load. With a properly designed shunt, it is, therefore, possible to throw heavy overloads off or on, without creating a lag in the change of field strength behind the armature current sufficient to cause excessive sparking.

INVERTED SYNCHRONOUS CONVERTERS: Inverted synchronous converters while not used frequently are sometimes desirable, as in a low-tension direct-current system, where it is desired to supply an outlying district with direct current. This can be done by converting from direct to alternating current, transmitting as alternating, and then reconverting to direct current. Converters may also be used as a connecting link between alternating-current and direct-current generating systems so as to shift the load from one to the other, or inverted converters may be used simply to produce alternating current.

The speed of the machine when converting from alternating to direct current is fixed by the frequency and cannot be varied by altering its field excitation; this would merely change the power factor. However, when converting from direct to alternating current, the speed depends upon the field strength, being increased by a weak field and decreased by a strong field except when tied into an alternating-current system. It is evident, therefore, that there should be little or no series field on an inverted converter, or it will change in speed under load and deliver alternating current at variable frequency.

A lagging alternating current weakens the field, and thus increases the speed and frequency so that under certain conditions, as with an inductive load, the converter may reach a very high speed. Therefore, care should be taken to see that the field excitation is always large enough to prevent excessive speeds, especially when a second converter is operated from the inverted one to change back from alternating to direct current. Speed-limiting devices should always be furnished with synchronous converters used under these conditions. Separate excitation of inverted converters is also desirable, in which case the exciter should be mechanically driven from the converter. An increase in the speed will increase the exciter voltage and thereby the excitation of the converter, thus tending to check the speed.

Frequently, inverted converters are operated in parallel with alternators. In such cases, the danger of racing does not exist, if the generators and their prime movers are of such size that they cannot be carried away in speed by the converter. It is important, however, to investigate the speed regulation of the prime movers since the inverted converter runs at a uniform speed and if the alternators are not operating at constant speed, cross-currents will result.

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The McMillan Smokeless Furnace

A new furnace of the dutch-oven type, designed to burn coal smokelessly, has recently been perfected by James McMillan & Co., 33 North Market St., Chicago. It is made up of a flat shaking grate, with inclined coking grates at either side, and a firebrick roof covered with asbestos and sheet metal.

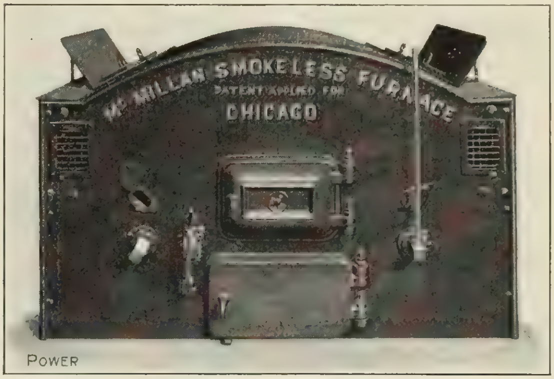

FIG. 1. FRONT OF McMILLAN SMOKELESS FURNACE

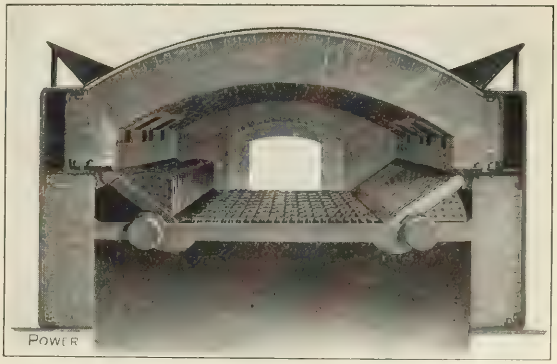

FIG. 2. VIEW OF FURNACE FROM THE FRONT

Fig. 1 shows the furnace front and Fig. 2 is a view looking into the rear of the furnace. From the latter view the general arrangement will be evident. The furnace may be adapted to nearly every make of boiler for capacities ranging from 20 to 200 hp.

Coal is fed through the top of the furnace on either side and is allowed to remain on the inclined coking grates until it has been freed of its volatile matter. Air, introduced through the perforated plates on the furnace front and admitted along the fuel bed, mixes with the gases distilled from the coal, and the mixture is burned without smoke as it passes over the incandescent coal on the horizontal grate. When the green coal has been thoroughly coked, it is shoved over on the flat grate by transfer bars fitted in the openings of the inclined grate. These bars are pivoted on a rod turned by the handle shown at the front of the furnace, and are curved at the outer end so that in any position they close the openings through which they project and prevent fine coal from falling through to the ashpit.

With this type of furnace there is no occasion to open the top door except for the removal of clinkers, so that the conditions are uniform and the drop in efficiency common to the usual hand-fired furnace during the firing interval is obviated. The air for the combustion of the coal on the horizontal shaking grate is supplied through the ashpit door as usual.

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American-Ball, Four-Cylinder, Triple-Expansion Engine

A new high-speed engine for driving centrifugal pumps, built by the American Engine & Electric Co., Bound Brook, N. J., is of the triple-expansion type, with four cylinders. The illustrations show a 1000-hp. engine. The steam conditions for this unit were 250 lb. initial pressure and 25 in. vacuum. The engine is of the double-angle type. Fig. 1 shows how the two engine frames are bolted together and the small floor space required by a 1000-hp. engine.

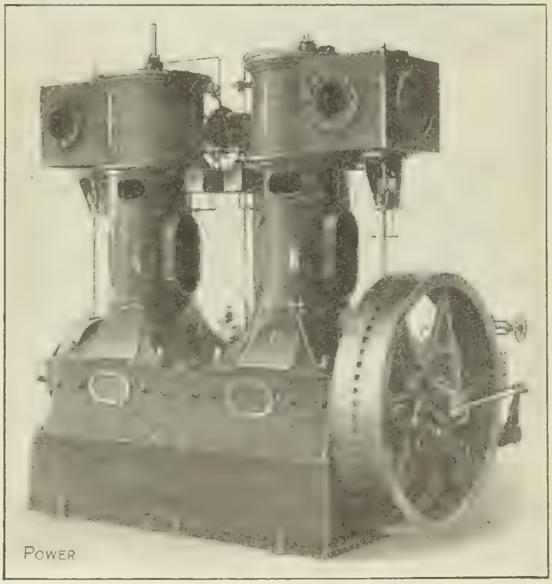


FIG. 1. REAR VIEW OF THE AMERICAN-BALL FOUR-CYLINDER ENGINE

The high-pressure cylinder is in the foreground, Fig. 2, the intermediate cylinder to the right, the low-pressure cylinders are vertical. This construction gives a large ratio of expansion and, therefore, high economy; it also eliminates a large low-pressure cylinder with its massive reciprocating parts. With a single large, low-pressure cylinder, the speed would have to be materially reduced, and this would increase the size, weight and space required by the engine. The increase in weight would in turn necessitate a decreased speed.

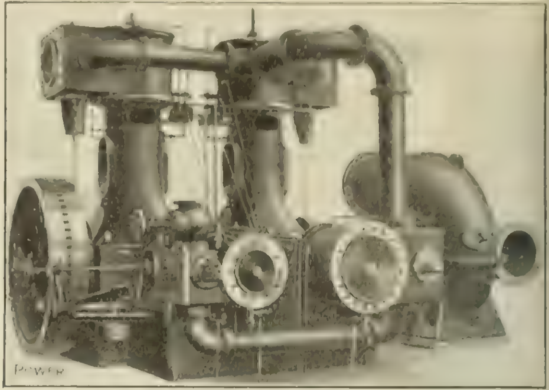


FIG. 2. FRONT VIEW OF AMERICAN BALL, FOUR-CYLINDER, TRIPLE-EXPANSION ENGINE

Higher speeds may be used with the four-cylinder construction because of the smaller size of the two low-pressure pistons and rods and as the inertia forces of the vertical reciprocating masses are opposed and balanced by equal and opposite forces from the horizontal cylinders. This advantage of the angle construction is now well known. The four-cylinder, triple-expansion engine is another application of the same design.

Vibration and pounding are eliminated, even at very high speeds, so that the foundations may be light and inexpensive. For stationary plants, a simple block of concrete is all that is necessary. For example, a 1000-hp., four-cylinder, triple-expansion engine would require about 25 cu.yd. of concrete for its foundation.

The design of the valves, pistons, crossheads, rods, etc., of these engines is similar to that of the angle-compound engine. All the parts are supplied with oil from two central storage tanks, between the two vertical low-pressure cylinders, Fig. 1. The oil collects by gravity, is filtered and then returned to the elevated tanks by two pumps operated by the valve-gear rocker-arms of the horizontal cylinders. One of these pumps with its plunger can be seen to the left in Fig. 2.

There are indicator cocks for all four cylinders and a permanent reducing motion on each crosshead. The governor is the standard American-Ball inertia type, of use principally to prevent a runaway in case the load is seriously reduced by the clogging of the pump inlet.

◆

Highest Powered Water Turbine—The highest powered water turbines ever built are the 22,500-hp. units recently constructed for the Washington Water Power Co. They will have an overload of nearly 25,000 hp. each. The builders, the I. P. Morris Co., are also constructing several 20,000-hp. vertical single-runner turbines for the Laurentide Co., Ltd., and nine, 10,800-hp. turbines for the Cedar Rapids Manufacturing & Power Co.

Editorials

What Can the Engineer Get?

A suggestion characteristic of the engineers' unwritten code of ethics is embodied in a letter on page 528 of the April 14 issue. In his reference to the results accomplished by "Engineer Wise," W. H. Odell says under the caption, "What Did the Engineer Get?" in the beginning of the second paragraph. "It may seem sordid," etc. This is professional pride. It is the trait of character or call it professional ethics, which is so frequently met with among engineers as to properly be called a fixed quantity or a constant. It entitles them to a high place in the scale of professions. They seldom discuss possible economies in the plant with any thought of profit to themselves. Who can remember such a suggestion on the floor of a lodge room (or anywhere else for that matter)?

Few of the professions equal, and certainly none excel in this characteristic. The lawyer is perhaps most frequently retained on a contingent basis, and the doctor the least. (A fee on the kill or cure basis might prove embarrassing to collect if the patient failed to recover). But the engineer performs all that he is nominally engaged to do, and besides, often effects economies as cited in the original article referred to, and expects no financial returns. All of which is splendid in itself, but does not furnish the present-day necessities nor do justice to his dependents.

There is enough brain in the craft and enough professional and financial standing if properly centered and utilized to enable the engineer of any plant to secure expert advice on his specific case to enable him to go to his employer with well developed plans of action or changes in order to produce results either in the line of extensions or economies with the straightforward business proposition that he is to benefit by it in a direct definite proportion to his employer. The plan is easy of execution through any of our engineers' organizations. Men of high standing are available to consult with and verify the possibilities of any given case and few are the plants which cannot show a handsome return on an investment which the engineer will be able to point out if properly received.

Employers will do well to give their engineers to understand that they will entertain suggestions along these lines. What a careful going over the old plants would have and best of all to the benefit and therefore the satisfaction of employer and employee. This is the life and solution of the isolated-plant problem; working along the lines of the central stations. State the case as the central station solicitor would state it. If within his heating zone, he would furnish heat and electric current each at a certain rate. If the isolated plant and engineer can do better, let them bid against the central station.

Rather than abandon his plant for "street current," almost any employer would prefer to make a contract with his own engineer to run the plant at less than central station rates, and to share the saving with the engineer. The bringing of this about is simply a question of the assertiveness of the engineer in urging his proposition, and the confidence of the employer in his ability to carry it out.

"Safety First"

During the past year many industries and corporations have concentrated the efforts of their ablest men on the "safety-first" movement—devoting time, thought and money toward means which would tend to eliminate by education conditions which are productive of accidents.

It has been well said that "accident prevention saves misery and money."

Until quite recently, this twofold saving has not been duly appreciated and in striving to increase output and sales the avoidance of accidents has been overlooked as one of the factors reducing the cost of operation. Employers have been somewhat slow in awaking to the fact that most accidents can be avoided, and do not seem to have seriously considered the great double saving to be effected through prevention.

An accident removes from his place for the time being the man his employer considers most capable in the line of work in which he is engaged. Through an injury the employer loses his man's services and must replace him, temporarily at least, with a less able man. Such an interruption cannot fail to show its effect on the efficiency of the factory or plant. It disturbs the productive power and brings suffering into the family of the injured.

A catastrophe avoided means lives saved and receivership averted. We can never reach a point where occupational accidents, or those accidents to labor, can be entirely eliminated, but it is the opinion of those well informed that the absence of systematic prevention work will cause the employer to contend with 30 to 40 per cent. more accidents.

Most of the conditions regarded as likely to cause accidents are not due to mechanical or electrical defects, but as a rule to simple hazards, easily removed. A workman's sense of prevention seems to be more one of avoiding an accident himself than of removing the cause of the accident, not only to himself, but to other employees as well. Telling workmen to be careful or oft-repeated warnings do not seem to have proved effective, but in using the experience of others and in applying the lesson directly, the workmen become aroused to the fact that they are the greatest losers through preventable accidents.

The greatest factor operating toward the prevention of accidents is not the prevention device but the prevention "spirit."

The Pennsylvania Railroad Company has reduced its accidents ninety per cent. in the past year as a result of the "safety-first" movement among its employees.

Report on Municipal Ice Plants

Many will remember that in the summer of 1913, Borough President George McAneny, of Manhattan, New York City, seriously considered the manufacture and distribution of ice to ameliorate the suffering among the poor during the hot months. That the problem might be thoroughly considered, a report on municipal and government ice plants in the United States and other countries, prepared by Jeanie Wells Wentworth, has been submitted to Borough President Marks, Mr. McAneny's successor.

The report reveals the fact that but one municipally owned and operated ice plant, in Weatherford, Okla., was discovered. The plant is operated in connection with the water and light plant, using the exhaust steam from the pumps and engines. The manufacturing cost is fifty cents per ton, forty cents of this being for labor and ten cents for fuel.

The report shows that for the years 1907, 1908 and 1909 the average cost per ton of ice for the Government Post Office Department, the Washington City Post Office and the Government Auditor's Office was $5.11. This is based on the consumption of 470 tons per season, which is from June to September inclusive. Careful estimates showed that the same quantity could be manufactured and delivered for $1033.06, or $2.198 per ton, resulting in a saving of $1368.64.

It appears that the high and increasing price of purchased ice forced the government departments to install ice-making machinery in department plants. The following quotations from a requisition by the Secretary of the Treasury for $3500 to install an ice machine in the Treasury Building is interesting: "The Treasury Department and outlying offices now (1909) use about 1,200,000 pounds of ice annually, and at the price quoted for the coming fiscal year (34 cents per 100 pounds in small quantities) the appropriation would not be sufficient to meet requirements." The total consumption at 34 cents per 100 pounds equals $4080.

After three years of governmentally operated ice plants, the report enables one to calculate that for 1913 the cost of manufactured ice for the Treasury Department is $2.00 per ton; for the Post Office Department, $2.42; for the Treasury Department, $3.90; for the State, War and Navy departments, $3.60. The savings per ton for these departments are $4, $2.18, $1.70 and $2 respectively. The total saving for the four departments for 1913 is $9672.90. All plants use live steam in the ice machines.

The subsistence department of the Isthmian Canal Commission produces about 110 tons of ice daily in the plant which it operates in the Canal Zone. With fuel costing from $4.15 to $4.20 per ton, and with high labor costs, the plant produces ice for $1.63 per ton; this includes part of the overhead charges.

After passing through the machines the steam, or rather condensate, is filtered and used for ice making.

The reports from plants abroad are not interesting as there seems to be a general lack of itemization of charge. This is especially true of England. The practice abroad is to charge about market price and turn the profits into the city treasury.

The Borough of Manhattan is now investigating the cost of harvesting ice outside the city and shipping it in as compared to manufacturing it.

Engineers of office and public buildings would do well to enter in their notebooks the ice data covering the government buildings. The figures will go a long way toward convincing the owners of institutions requiring ice or refrigeration of the advisability of installing their own ice plants.

* * *

When Ignorance Is Folly

Is ignorance a disgrace? That is a question which can be answered both ways; sometimes it is and again it is not, depending on circumstances. Whatever knowledge a man has never had occasion or opportunity to gain, he cannot be blamed for lacking. There is altogether too much to be known for anyone to "know it all." While there is a difference in capacities, no human brain can hold more than a wee bit of all there is to know. Consequently, it is almost as important to avoid loading up with useless knowledge as to seek that which is useful. The wise one is he who selects carefully. Ignorance of things there is no reason to know is, therefore, no disgrace.

Then when is ignorance a disgrace? Briefly, it is when its existence is realized and no effort is made to overcome it. There is a moral of an old fable which runs: "If a man fools me once, shame on him; if a man fools be twice, shame on me." By the same token, the first time a man discovers his ignorance of something he should know, it is no reflection upon him, but if he again finds himself wanting that knowledge, and in the interval has had the chance to get it, he deserves to be ashamed.

This leads up to the main thought, which is this: Don't be afraid to ask questions. Don't sit and look wise, and let the opportunity go by to learn something you need to know, because you are "ashamed to show your ignorance." The probability is that you make more of your want of information than anyone else. No decent fellow ever thought any less of another who confessed ignorance. On the contrary, it is quite in the nature of things to admire the chap who has the backbone to come out and say. "I don't know; tell me." Even if it is mortifying to expose one's ignorance, it is far better to do it once and have it over with than to go on not knowing and be again embarrassed, perhaps at a more critical time.

Times are fortunately changing in regard to the disposition to hide ignorance. In the early days of engineers' associations it was common to hold back the questions that many wanted to ask. As a consequence, discussions lagged, and little of interest, beyond what the lecturers offered, was brought out. Today, the discussion following a paper is likely to develop more of real value than the paper itself, because more and more, since the ice was broken, are those of the audience taking part.

If any encouragement is needed by those who are still backward, let them weigh the truth of this paraphrase of a familiar adage:

There is so much knowledge in the worst of us and so much ignorance in the best of us, that it hardly behooves any of us to criticise the rest of us.

* * *

The salesman on the right in the cartoon this week is getting two orders, anyway—"Get out!" and "Stay out!" and he deserves both of them.

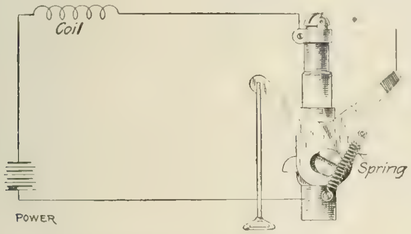
Correspondence

Self-Induction

Referring to Mr. Meade's article in the Feb. 17 issue, on "Calculating Power in Alternating-Current Circuits," attention is called to the common type of gas lighter or cigar lighter as illustrating self-induction. The current is supplied from two or three dry cells with a coil in series, as represented in the sketch.

In any coil the current rises to full value rather slowly, due to self-induction. That is, as the circuit is closed, the current rushes into the coil; but the lines of force set up produce an electromotive force in opposition to the electromotive force of the battery. Hence the effective electromotive force is the difference between that of the battery and that produced by self-induction, and the flow of current is checked.

When the circuit is opened the lines of force surrounding the coil, decrease rapidly; hence the electromotive force of self-induction is in a direction opposite to that set up when the circuit was closed and the lines of force were increasing. That is, the electromotive force of self-induction is now in the same direction as the electromotive force of the battery and the result is a greatly increased spark.



Electric Gas Lighter

A similar example is found in the inductive spark when opening a generator-field circuit when the machine is running. A transformer with an open secondary also illustrates the effect of self-induction, for it is this that limits the current flowing through the primary.

J. S. Dodds.

⁂

Hammering Check Valves

I do not think enough particulars are stated by A. E. Walden, in the Feb. 10 issue, under the above title. Many things may cause this trouble; for instance, the location of the checks, some systems having them on the return pipes of every radiator. Assuming that the checks complained of are at the bottom of the return risers, it is possible that the return pipes have pockets, or that some risers are using more steam than others, causing different pressures.

In my opinion, a system discharging into a receiver will give just as good results without a check. I once had this same trouble, but after removing the checks I never had any more. Perhaps the receiver vent pipe is too small. One could give a number of reasons for hammering check valves, but so many things are possible to affect the operation of a heating plant that it is difficult to offer suggestions that may be of value without fullest information of the layout of the heating system.

H. A. Whitaker.

West Somerville, Mass.

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Engineers' License Law Needed

If there is any state in the Union that needs to have licensed engineers it is West Virginia. Four or five of our largest towns have what they call city license laws, which are administered by the police departments, but as long as this continues no good results are possible.

I have worked in the state about 15 years and have had some funny experiences with men. A short time after I took charge of one plant the night man quit without giving notice. The superintendent told me he would send a man up to run the plant that night. When the man came he told me that he had worked in the mines and at carpenter work. About 10 o'clock he blew the whistle, and I hurried over and found him in the boiler room on a ladder at the water column. He had blown down the boiler, and the water was out of sight in the glass. The result was I had to put 18 new tubes in the boiler, which was a 250-hp. Stirling.

The boiler inspector called around one evening and he told me the following day about his talk with the night man. He said, "Why that man is dangerous to have in a plant like this. When I asked him how much steam pressure he was carrying, he told me he was only carrying 125 lb., but could carry a lot more if he wanted to, as the steam gage would carry 250 lb." When I quit, about eight months after he went to work as night man, the superintendent put him in charge as engineer.

At a coal-mining plant one morning when the day man relieved the night man he found that the water was out of sight, and the crown-sheet burnt; all the tubes had pulled loose and the soft plug was melted, but it was covered over with scale a quarter of an inch thick, which had to be broken with a punch.

Even after this the superintendent put a young man on the night shift, who had never been around boilers, and knew nothing about them.

Not long ago I was down at a sawmill, where they were using an old fire-box boiler, from which the gage-cocks had been removed, and the holes plugged, and I would hate to vouch for the steam gage. I asked the fireman how he could tell the height of water in the boiler, and he replied that he did not know for sure, but kept the pump running all the time, and if the water got too high and went over in the engine he could let some of it out. He did not say what he would do if the water got low. In fact, there was no way of telling the water level.

Now I do not mean to say that there are no first-class engineers in the state, because there are, but they have to compete with and work for a third- or fourth-class man's salary, which is about $50 to $60 per month. I know of one engineer who runs a plant, which has three boilers of 1000 hp., two alternating-current generators, one large direct-current outfit for street-car service, one motor-generator set, and three pumps, and does his own firing for $60 a month. He works 12 hr. per day for $720 a year, not quite 17c. an hour. The pay for common labor is $1.75 to $2.25 a day of 10 hr. What encouragement has a man to study and work a lifetime, trying to qualify himself to be a first-class engineer, when they pay as much or more for common labor? The company that hires incompetent engineers pays out more money, including repairs, in a year than if only first-class men were engaged at good wages.

WALTER B. BLAIN.

Belington, W. Va.

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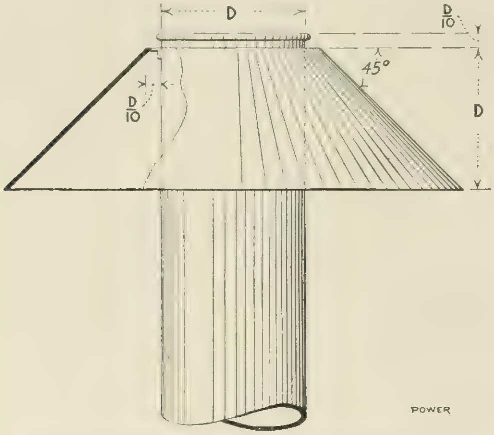
Device Improves Stack Draft

The arrangement described herewith is one which makes use of the potential energy in the winds blowing about a stack to improve the draft, and is especially suitable where the winds ordinarily tend to impair the draft of a stack, as where a large expanse of flat roof surrounds it. Even in the case of a down draft on the stack, the arrangement will help eliminate the bad effects.

The arrangement consists of a collar of iron of frustrum form, attached to the stack close to its upper end. The collar should be spaced a slight distance away from the stack by suitable straps, so that up-coming currents of air can readily pass between the frustrum and the stack. The general proportions of the collar, expressed in terms of the stack diameter, are indicated on the sketch.



HOOD ON STACK TO IMPROVE DRAFT

The action of the arrangement is as follows: Horizontal winds are guided upward and create a vacuum about the end of the stack and improve its draft. Winds or currents going up under the collar will be compressed as they approach the top of the stack, owing to the wedge shape of the collar, and will exit through the top and by the open end of the stack with speed, assisting at the same time the currents flowing up on the outside of the collar. The collar will also act as insulator for the end of the stack and thus keep the gases at the point at a higher temperature. A downward flow of air currents on the stack will be broken and guided out from the stack, so their effect will be diminished.

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Boiler-Blowoff Accident

This letter is intended to bring before operating engineers and boiler inspectors a most unusual condition found by the writer recently in one of Philadelphia's leading hotels. It was a daily practice at this plant to blow down about 2 in.

The blowoff arrangement was of the usual design, a plug cock nearest the boiler and a valve about 2 ft. away. The engineer had opened the valve and started to open the cock. When about half-way open the stem broke off, the top part of the stem and the handle coming away in his hand.

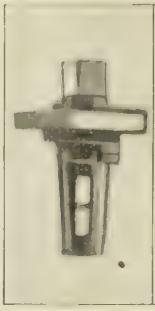

FIG. 1.

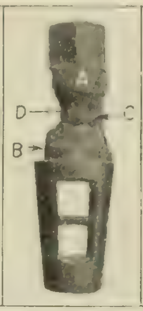

FIG. 2.

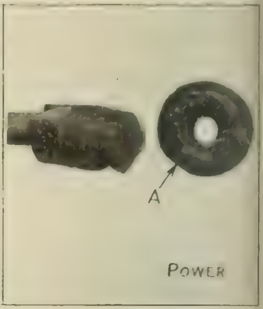

FIG. 3.

Under ordinary conditions this would not have been serious, because the valve could have been shut and the water retained in the boiler, but in this instance the conditions were so unusual that in 20 min. the two boilers were emptied, the water escaping through the fractured end of the plug. Prompt action saved the boilers from injury. When the water was all away an examination of the plug cock showed an inch hole in the stem, leading directly from the port in the plug to the point of fracture. Later, when the broken plug was taken from the body of the cock, another serious condition was observed, and perhaps more likely to be found than that shown in Fig. 1. There had been a most extensive corrosion taking place under the gland.

From Fig. 1 one would imagine that it was a new cock, for the metal above and below the gland is in perfect condition, as clean as on a new plug and the edges all perfect, but when the gland is removed, see what has taken place between the top of the gland and the top of the packing, Fig. 2.

It is assumed that some strong corrosive had entered from an outside source and laid on the packing, which was in perfect condition.

Fig. 3 shows the inch hole in the center stem *A*. It is as clean as though drilled, and perfectly round. The break shows clean, too, there being no sign of a crack or a leak through the pores of the iron. No serious damage was done, although the engineer was slightly scalded on the face. All blowoff cocks found with a hollow stem should be condemned and removed. One with a worm and gear opening attachment is preferable, it can be opened easily and gradually and there is no danger of opening suddenly, as may be done by a lever.

R. W. Robinson.

Germantown, Penn.

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Care of Boiler during Shutdown

A striking example of the bad effects resulting from the frequent practice of allowing a boiler to stand full of water during a shutdown has recently come to the attention of the writer. Two 260-hp. water-tube boilers were shutdown in April, filled with water at that time and allowed to stand idle until December. Upon inspecting these boilers, preparatory to starting up, a coating of about $\frac{1}{32}$ in. of rust was found covering the outside of the tubes. To remove this scale by scraping would have been an almost endless job, so a flat nozzle was made at the end of a ¼-in. pipe and compressed air used. This stream of air removed the coating of rust nicely but the plant was subject to delay in starting up besides the damage to the tubes.

The rust is caused by "sweating," or the condensation of moisture from the atmosphere upon the tubes, and occurs whenever the temperature of the tube or the water in the tube is lower than that of the surrounding air. The proper way to prepare a boiler for a shutdown is to clean it thoroughly, both inside and out, drain it of water and remove the manhole covers, allowing free circulation of air to all parts of the boiler. This applies to fire-tube as well as water-tube boilers.

F. E. Worley.

Providence, R. I.

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Where Should the Oil Separator Be Located?

In answer to the article under the above heading, in your issue of Mar. 31, by G. S. Sprague, I beg to submit the following which may help him and other Power readers:

An oil separator of the type shown should have an efficiency of from 95 to 99 per cent. elimination of the total quantity of oil used. There seems to be no reason why much better results are not obtained with it in its present position, provided, of course, it is large enough for the service.

I do not agree with the "rival salesman" that "no separator so located would work satisfactorily," or that the separator should get the steam as free from water as possible. It is a well known fact that oil can be removed more effectually from wet than from dry steam. Perhaps Mr. Sprague is using an oil which is too volatile, thus allowing some to go through the separator without striking the baffles at all. A common trouble is imperfect drainage, but this one, we are told, is well drained. The baffles should be frequently cleaned.

J. E. Poche.

New Orleans, La.

The writer designed a plant in which the location of the separator in reference to the engine is almost identical to that shown in Mr. Sprague's sketch. This plant has been in operation for over a year and the boilers show no sign of oil having passed the separator during that time.

As a matter of fact, the location of an oil separator is not of great importance, while the design of it is everything. One of the most efficient types is one in which the velocity of the steam is reduced to a few hundred feet per second and provided with suitable fluted baffles to catch the oil. For a 7-in. pipe it should be about 24 in. in diameter and 5 ft. long.

The type Mr. Sprague has, as indicated by his sketch, is so small that the velocity of the steam is too high and the travel too short to remove all of the oil.

I should advise Mr. Sprague to replace his present separator with one of known efficiency. If this is done no further trouble with oil should be experienced.

W. L. Durand.

Brooklyn, N. Y.

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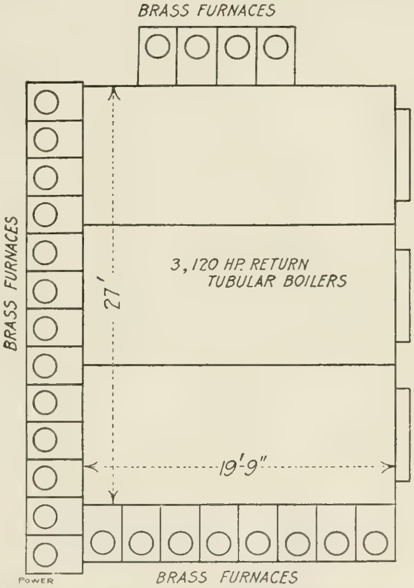
Brass Furnaces around Boiler Setting

At a plant in Iowa is a novel arrangement of brass furnaces in connection with boilers. As seen from the diagram, these furnaces are grouped directly around the boiler settings, there being eight on one side, four on the other, and 13 at the back. These furnaces discharge directly through short flues into the setting, all openings being back of the bridge-wall; thus the hot gases sweep through the boiler tubes and to the stack. An average of 14 of the brass furnaces are in continuous operation, anthracite coal being fired.



Boilers Using Waste Heat from Brass Furnaces

Many engineers have expressed their opinions on the relative evil or beneficial results from these furnaces as arranged, their claims ranging from 10 to 15 per cent. loss to 30 or 40 per cent. gain. Until recently there was no definite information as to what the results really were, until the writer made a few simple tests, using bituminous coal on the boiler grates and anthracite in the brass furnaces.

The steam-generating plant consists of three 120-hp. return-tubular boilers, arranged side by side, as shown, the grate area of each boiler being 27½ sq.ft. Several 24-hr. tests were run on different days, the coal fired being carefully weighed and the feed water measured by a hot-water meter. The results showed an average coal consumption on the three grates of 778 lb. per hr., and an evaporation of 7351 lb. of water per hr., making an evaporation rate of 9.45 lb. of water per lb. of coal. At this rate 9.4 lb. of coal were being consumed per square foot of grate surface per hour, the coal being a good grade of bituminous.

That the furnace conditions were far from ideal was evidenced by the average flue-gas analysis, which showed 5.5 per cent. of CO_2. It would, therefore, seem that the excellent evaporative rate was due to the use of heat from the brass furnaces. The average steam pressure is 100 lb. per sq.in. With a feed-water temperature of 202 deg., the evaporation rate gives an equivalent evaporation from and at 212 deg. of 9.92 lb. of water per lb. of coal. It is anticipated that these results can be improved by stopping numerous leaks in the boiler setting, and completing an induced-draft system now being installed. The present stack is inadequate for the load, as it is but 28 in. square on the inside and about 80 ft. high. The induced-draft system will have a 90-in. exhaust fan, directly connected to a vertical engine, the fan and engine being mounted on the boiler-house roof in a small house. Dampers are so arranged in the breeching that the furnaces may be either switched from the stack, or the fan, or two furnaces may be run on induced draft and one on natural draft.

GRANDON D. GATES.

Dubuque, Iowa.

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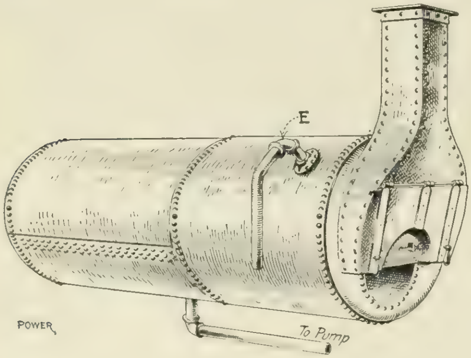
Forced Circulation

To avoid leaks from unequal expansion in Scotch boilers, marine engineers often connect to the suction of the feed pump a bypass from the bottom of the boiler, as shown in the illustration.



CIRCULATING PIPES

Some water is thus drawn from the bottom of the shell and returned at the regular feed point *E*, which tends to equalize the temperature throughout. This is especially desirable when getting up steam.

C. R. MCGAHEY.

Baltimore, Md.

The Language of Ordinances

Your editorial, under the above title, in the Mar. 17 issue, is interesting and pertinent. As the language of the ordinance, although probably the work of one man, was acted upon by the council, every councilman stands arraigned, since any one of them could have challenged it. Probably, also, it was furthered and viséed by several men connected with steam-plant practice in Reading. Be this as it may, the main responsibility is certainly upon the councilmen.

It is a matter of regret that the standard of engineering English is as low as it is, although certainly it is improving, and at a rapid rate. Certainly, also, the engineering magazines have done and are doing much toward this end. Although it is sometimes true, it is always difficult to believe that clear thinking can be an accompaniment of slovenly writing.

H. L. H. SMITH.

Brooklyn, N. Y.

⁂

Core Water Cools Ammonia

The place utilizing the following plan of cooling liquid ammonia was a raw-water ice plant having the usual apparatus for pumping the core water out of the ice cakes just before they are formed, and filling the centers with distilled water to produce clear ice.

The core water pumped out leaves the cans at 32 deg. F., and runs through an open-box flume to a near-by stream. The ammonia condenser and liquid receiver are quite some distance from the freezing tank and near the flume carrying the core water from the tank. The liquid line between the ammonia receiver and expansion header on the freezing tank was run about four-fifths of this distance submerged in the cold core water, which delivered the liquid ammonia to the expansion valves at a much lower temperature than that at which the ammonia was condensed in the condensers.

Of course, this cold water for cooling the liquid ammonia is available only at such times as the ice cakes are being pumped out, but this extends over quite a period when the plant is in full operation. The installation of this liquid cooler has paid for itself many times.

C. T. BAKER.

Jacksonville, Fla.

⁂

Boilers to Cool Jacket Water

It might interest some readers to learn that it is quite satisfactory to use steam boilers for cooling gas-engine jacket water.

The company with which I am connected has a combination gas engine and steam plant, and two idle boilers, one a 100-hp. fire-tube, and the other a 150-hp. water-tube are used to cool the jacket water. The water is circulated by a 1-in. direct-connected, centrifugal pump, into a sight-feed funnel and then distributed to the boilers in proportion to their cooling capacity. The dampers, of course, are kept wide open.

The outlet is at the blowoff and the water is put into the boiler as far as possible from where it is taken out. The gas engines are 125- and 80-hp., Westinghouse three-cylinder vertical units.

N. E. WOOLMAN.

Kittanning, Penn.

Inquiries of General Interest

To Detect Cutting of Brasses—How can cutting of crank-pin brasses be detected without removing them for examination?

S. J. G.

After the engine has been running awhile take some of the oil that has worked out of the brasses and spread it on a piece of white paper; if the brasses are cutting, fine particles of the metal will be found.

Pressure in Pump Air Chamber—Neglecting pressure due to friction in the discharge pipe, what is the pressure per square inch in an air chamber on the discharge side of a pump in pumping water against a head of 67.6 ft.?

W. D.

The pressure for each foot of head of water is equivalent to 0.433 lb. per sq.in. and the air-chamber pressure would be

$$67.6 \times 0.433 = 29.27 \text{ lb. per sq.in.}$$

Pump Water Cylinder Length—Why is the water cylinder of a pump made longer than the steam cylinder?

J. R.

So there may be plenty of clearance space for easy flow of the water into or out of the cylinder when the piston is near the end of its stroke and to afford latitude for adjustment of the stroke of the piston rod with reference to the stroke of the steam piston and proper equalization of steam-cylinder clearance.

Higher Boiler Efficiencies with Oil Fuel—Why are higher boiler efficiencies obtainable with oil fuel than with coal?

A. J. S.

With oil fuel the furnace doors need not be opened while the boiler is under steam, and with proper regulation of burners the oil can be burned with admission of little more than the amount of air necessary to furnish the oxygen necessary for the combustion; and the heating surfaces are not so quickly fouled by soot.

Determining Condition of Check Valve—In a low-pressure steam-heating plant how can it be determined whether the noise made by a check valve on a radiator or a dry return connection is due to ordinary operation of the check or to its derangement?

J. M.

If the valve is in proper working order it will remain closed and will prevent back flow when the supply is cut off from the radiator or other part of the system discharging through the check valve. If the check is not working properly, back flow would cause the radiator or return to become filled with water.

Direct vs. Indirect Spring-Loaded Safety Valves—What is the difference between a direct spring-loaded and an indirect spring-loaded safety valve?

J. C. A.

A direct spring-loaded safety valve is one in which the valve is held down by the direct action of a spring, while an indirect spring-loaded safety valve is one in which the spring holds the valve down through levers or other mechanism between the spring and the valve. An ordinary ball-and-lever safety valve having the lever held down by the tension or compression of a spring would be an example of an indirect spring-loaded safety valve.

Stopping Position of Crank—In shutting down an engine why does the crank stop a little past dead center oftener than at any other point of the stroke?

J. W. D.

When an engine is stopping, most of the momentum being in the flywheel the latter is driving the connecting rod, crosshead and piston. The velocities of the reciprocating parts, relative to the flywheel speed, rapidly decrease as the dead center is approached, consequently the load on the flywheel is then diminishing so there is less tendency to stop. Immediately the center is passed, however, these conditions are reversed and the stopping effect of the reciprocating parts becomes greater and greater until midstroke. Therefore, if the engine gets by midstroke it is likely to keep moving until the next dead center is passed.

Boiler Horsepower Developed—A boiler consumes 280 lb of coal per hour, the coal having 14,000 B.t.u. per pound. Assuming that 70 per cent. of the heat of the coal is utilized in making steam, what boiler horsepower is developed?

C. C. W.

The heat realized would be:

$$70\% \text{ of } (280 \times 14{,}000) = 2{,}744{,}000 \text{ B.t.u. per hr.}$$

A boiler horsepower is equivalent to the evaporation of 34½ lb. of water per hour from and at 212 deg. F., and the net amount of heat required for one boiler horsepower is

$$34\tfrac{1}{2} \times 970.4 \text{ B.t.u.} = 33{,}479 \text{ B.t.u. per hr.,}$$

therefore the boiler horsepower developed under the conditions stated would be:

$$\frac{2{,}744{,}000 \text{ B.t.u.}}{33{,}479 \text{ B.t.u.}} = 81.96 \text{ b.hp.}$$

Cracked Tube Sheet—Is there any way to fix up a crack in the tube sheet of a horizontal return-tubular boiler? The crack is between two tubes in the rear head and has been kept tight for a month by calking.

J. A.

A crack in a flue sheet indicates a weakness which might result in a serious explosion and the flue sheet should be renewed or the use of the boiler abandoned. We cannot commend any other repair as safe even though the boiler does not leak. It is possible, however, that the crack is such that it could not lead to serious damage, and if the owner and operator of the boiler are satisfied to take the risk, such a leak could be stopped, although not made any safer, by drilling and tapping a number of holes, about ⅛ inch diameter, the full length of the leak and close together, screwing in screws made of copper wire and then peening over their ends with a light hammer to make a tight calked joint. Such a repair may do for an emergency, but should not be depended upon longer than necessary.

Saving of Feed-Water Heater—In a plant where steam is generated at 90-lb. gage pressure and the temperature of the boiler feed water is 60 deg. F., and the exhaust at present wasted what would be the per cent. of saving if the temperature of the feed water is raised to 210 deg. F. by an exhaust steam feed-water heater?

H. C.

With feed water at 60 deg. F. each pound contains 60 — 32 = 28 B.t.u. above 32 deg. F., and as 1 lb. of steam at 90-lb. gage pressure contains 1187.3 B.t.u. above 32 deg. F., then to raise a pound of feed water at 60 deg. F. into a pound of steam at 90 lb. gage pressure requires the addition of

$$1187.3 - 28 = 1159.3 \text{ B.t.u.}$$

With feed water at 210 deg. F. each pound would require 210 — 60 or 150 B.t.u. less than with feed water at 60 deg. F. Therefore, if no additional back pressure is brought on the engine by using an exhaust-steam feed-water heater the saving would be

$$\frac{150 \times 100}{1159.3} = 12.94 \text{ per cent.}$$

Water Siphon—Is there any limit to the height over which water can be siphoned out of a reservoir?

C. G. L.

It is the pressure of the atmosphere which operates a siphon and it would be impossible to siphon water over a height greater than the height of a water column which would be sustained by the pressure of the atmosphere. At sea level and with a temperature of 62 deg. F. the pressure of the atmosphere is 14.7 lb. per sq.in., which is the same as the pressure per square inch at the foot of a column of water 33.94735 ft. high. With less atmospheric pressure, as in elevated localities where the barometric pressure is less a correspondingly less height of water column would be sustained and the water can be siphoned over a correspondingly less height. The siphon would not continue to operate if the height of the intake leg were greater than about 33 ft., because a vacuum space would be formed at the crest of the siphon, the flow would break at that point, and the action of the siphon would fail because the atmospheric pressure would be insufficient to elevate the water to the top of the inlet leg.

Engineers' Study Course

Elementary Mechanics—V

LAST LESSON'S ANSWERS

16. In Fig. 18, let OA equal the force of 100 lb. and OB the force of 80 lb. Construct the parallelogram $OACBO$ and draw the diagonal OC to give the resultant force R.

From equation 5, Lesson II,

$$R^2 = 100^2 + 80^2 + 2 \times 100 \times 80 \times cos\ 60\ deg.;$$
$$= 10{,}000 + 6400 + 8000 = 24{,}400;$$
$$R = 156.2\ lb.$$

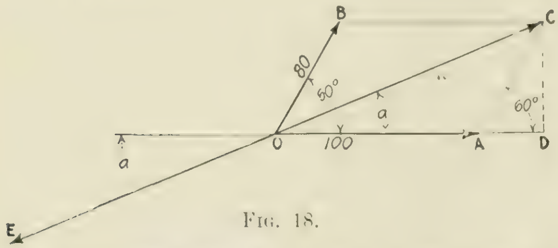


FIG. 18.

Draw CD perpendicular to OD then $CD = AC\ sin\ 60$ deg. = 69.3 and $AD = AC\ cos\ 60$ deg. = 40

$$tan\ a = \frac{CD}{OD} = \frac{69.3}{140} = 0.495$$

therefore, a = 26 deg. 20 min. The equilibriant of a system of forces is equal and opposite to the resultant of these forces. Therefore, the line OE, which is equal and opposite to OC, is the desired force and makes an angle of 26 deg. 20 min. with the horizontal.

17. Refer to Fig. 17 of last week's lesson. In this case the angle NOH = 35 deg. The line $ON = T$ = 2000 lb. and the line NH represents the unknown load W.

$$\frac{NH}{NO} = sin\ 35\ deg. = 0.574$$

hence

$$NH = NO\ sin\ 35\ deg. = 2000 \times 0.574 = 1148\ lb.$$

18. The tension in the link OB is the resultant of the weight W of the ball, and the centrifugal force C. In the triangle $BONB$ (see Fig. 15 of last week's lesson), the force OB is equal and opposite to the resultant of the weight W and the centrifugal force OF.

Also

$$NB = OE = W = 40 \text{ and } ON = OF = 30$$

therefore

$$OB^2 = T^2 = ON^2 + NB^2 = 30^2 + 40^2 = 2500$$

or

$$T = 50\ lb.$$

19. The tension in the tie-rod AC will be decreased since part of the weight W is now taken by the point B, where previously it was all taken by the point A.

20. The pressure at B will no longer be horizontal since part of the weight W is acting at the point B. The pressure on the point B is equal to the resultant of the pressure in the strut AB and the part of the weight taken by the point B. Draw a vertical line through the center of the line AB until it intersects the line AC. A line connecting this point with B will give the direction of the pressure on the point B. Proof: If three forces acting on a body produce equilibrium, the lines of action of these forces pass through a common point. (See Lesson IV.)

LAW OF SINES

From the lessons in trigonometry the student doubtless recalls the rule that in *any triangle any side is proportional to the sine of the angle opposite the given side.* (*Law of sines.*) This law can be used to solve the force triangle when it contains no right angle. For example, take the case of a weight W suspended from two tie-rods which are pivoted at the points A and B and make angles with the horizontal, as shown in Fig. 19. What will be the tensions in the rods OA and OB? Draw the triangle $OACO$ having the side AC parallel to OB and the side OC proportional and parallel to the weight W. In this triangle the side OA is proportional to the tension T_2 and the direction of the force is from O to A; AC is proportional to T_1 and its direction is from A to C; the side CO is proportional to the weight W and its direction is from C to O. Hence the three forces acting on the point O are represented by the sides of the triangle $OACO$ taken in order. By construction the angle CAB equals 30 deg. since AC is parallel to OB. Therefore, the angle ACO = 60 deg. (Note—The sum of all the angles

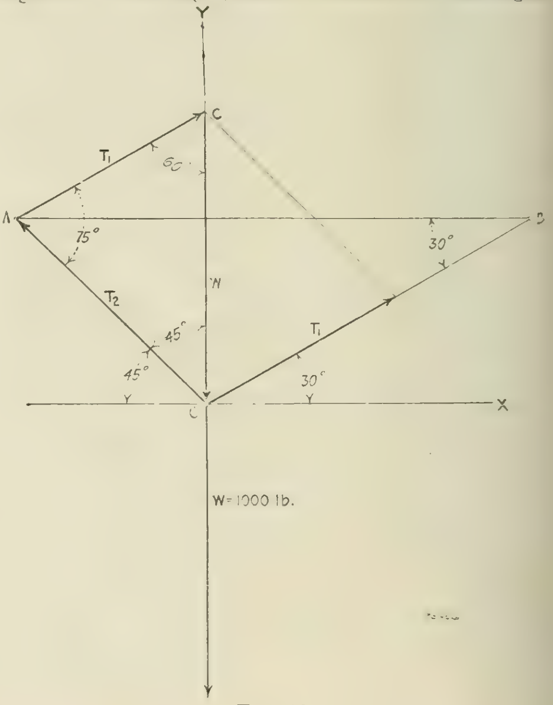
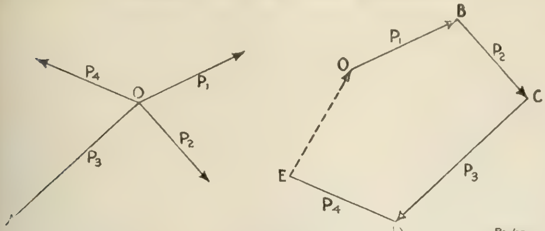


FIG. 19.

of any triangle = 180 deg.) For the same reason the angle *COA* = 90 deg. — 45 deg. = 45 deg. The angle opposite the side *CO*, or *W*, is 75 deg.; opposite the side *AO*, or T_2, the angle is 60 deg.; and opposite *AC*, or T_1, the angle is 45 deg. Now apply the law of sines and there result these equations



(a) FIG. 20. (b)

$$\frac{T_1}{sin\ 45\ deg.} = \frac{W}{sin\ 75\ deg.}$$

also

$$\frac{T_2}{sin\ 60\ deg.} = \frac{W}{sin\ 75\ deg.}$$

hence $$T_1 = \frac{W\ sin\ 45\ deg.}{sin\ 75\ deg.} = \frac{1000 \times 0.707}{0.966} = 732\ lb.$$

and $$T_2 = \frac{W\ sin\ 60\ deg.}{sin\ 75\ deg.} = \frac{1000 \times 0.866}{0.966} = 897\ lb.$$

For those who are familiar with the law of sines the above solution will be easy. For the benefit of those not familiar with the law the problem will now be solved by resolving the forces into their horizontal and vertical components and applying the laws $\Sigma H = O$ and $\Sigma V = O$. Use the point *O* (Fig. 19) as the origin and draw the two axes *OX* and *OY* through this point. The horizontal component of the tension $T_1 = T_1\ cos$ 30 deg. and the vertical component = $T_1\ sin$ 30 deg. Likewise the horizontal component of $T_2 = -T_2\ cos$ 45 deg. (this is minus because the component is acting to the left). The vertical component = $T_2\ sin$ 45 deg. The horizontal component of $W = W\ cos$ 90 deg. = 0 and the vertical component = —*W* (minus because *W* is acting downward).

Therefore.

$$\Sigma H = T_1\ cos\ 30\ deg. - T_2\ cos\ 45\ deg. + 0 = 0$$

then $$0.866\ T_1 - 0.707\ T_2 = 0$$

hence $$T_1 = \frac{0.707\ T_2}{0.866} = 0.8164\ T_2$$

also $$\Sigma V = T_1\ sin\ 30\ deg. + T_2\ cos\ 45\ deg. - W = 0$$

then $$0.5\ T_1 + 0.707\ T_2 - 1000 = 0$$

or $$0.5\ T_1 + 0.707\ T_2 = 1000$$

Substitute in this equation the value of $T_1 = 0.8164\ T_2$ and there results

$$0.5 \times 0.8164\ T_2 + 0.707\ T_2 = 1000$$

or $$1.1152\ T_2 = 1000$$

$$T_2 = 897\ lb.$$

and $$T_1 = 0.8164\ T_2 = 0.8164 \times 897 = 732\ lb.$$

By a comparison of the two solutions it is seen that the method of sines is much shorter than the method of components and for this reason the student is urged to study the law of sines and to combine it with the triangle of forces in the solution of subsequent examples.

POLYGON OF FORCES

Thus far only two- and three-force problems have been considered, but frequently problems will arise in which there are four or more forces acting at a given point. In such cases the principle of the triangle of forces is extended to include the *polygon of forces.*

Rule: If any number of forces in the same plane, acting at a given point on a body produce a state of equilibrium, these forces can be represented in magnitude and direction by the sides of a polygon taken in order. Conversely, if any number of forces in the same plane acting at a given point on a body can be represented by the sides of a polygon taken in order, the forces will be in equilibrium.

The polygon of forces can be used to determine the force necessary to balance a system of forces. In Fig. 20a, the four forces P_1, P_2, P_3 and P_4 act at a given point *O*. Do these forces produce equilibrium? In Fig. 20b, draw *OB* parallel and equal to P_1, *BC* parallel and equal to P_2, *CD* parallel and equal to P_3 and *DE* parallel and equal to P_4. There is thus formed the figure *OBCDE* which is not a closed polygon and hence the forces are not in equilibrium. A line drawn from the point *E* to the point *O* will represent the magnitude and the direction of the force required to balance the system. The student can prove the truth of this statement by applying the parallelogram law to determine the resultant of the forces P_1, P_2, P_3 and P_4 as explained in Lesson II. The force necessary to produce equilibrium will be equal and opposite to the resultant thus found, and must be equal to the line *EO*.

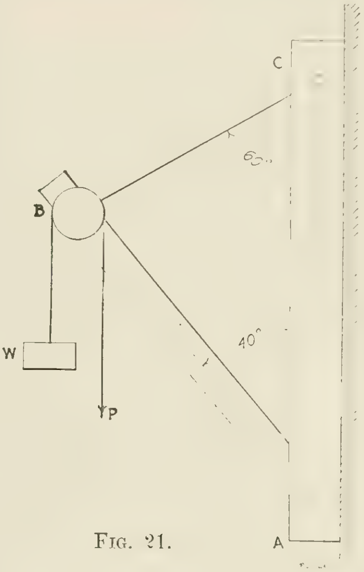


FIG. 21.

STUDY QUESTIONS

21. In Fig. 21 determine the tension in the tie-rod *BC* when the weight *W* = 600 lb. (Note: *P* = 600 lb.) Solve by the aid of a force triangle.

22. Find the compression in the strut *AB*.

23. What produce the reactions necessary for equilibrium in Fig. 21?

24. Using the magnitude and directions of the forces given in problem 10, Lesson II, and, replacing the resultant force of 144 lb. by an equal and opposite force, construct a force polygon.

25. Are the forces in problem 24 in equilibrium? Give a reason for your answer.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Over a million dollars worth of horses die each year in New York City, according to the New York Edison Co. If you'll be the goat, the answer is that this sum will buy a thousand electric trucks Whoa, Dobbin, here comes a truck!

⁂

Some speed! A projectile from a 12-in. gun travels at the rate of 25,000 miles a minute, being released at a pressure of 10,000 pounds to the square inch. It hits the mark ahead of its own sound.

⁂

A New Haven medico asserts that the average office boy wastes as much energy in walking about the office in a day as it would take to shovel 15 tons of coal. If the efficiency experts hear this, they will advocate putting office boys in the boiler room.

⁂

"Get the Personal Touch!" says an automobile advertiser. It's bad advice. And to make it worse, he further states, "Get the feel of the car!" Loads of people have already got the feel of a car, and afterwards hobbled around on crutches—if they were able to save the pieces.

⁂

There is an enormous demand for nicotine for spraying grapevines in France, says a consular report. It's a pity Jacques cannot import some of those engine-room "sprayers" we used to know. They, too, had an "enormous demand for nicotine"—usually off the other fellow's plug.

⁂

Oh, you great big beautiful New York! Your legislators, after an all-day and an all-night session, made "Packy" McCabe a Conservation Commissioner. We'll get conservation now, and then some! If we don't get the doughnut, we'll get the hole—and there are only two parts to a doughnut, anyhow.

⁂

Some Chicago scientists are making arrangements to weigh the moon. They're always trying some stunt out that way to get ahead of the effete East. All winter we've been trying to figure out how 16 hundred-pound bags of coal make a ton.

⁂

Hooray for the grape-juice government! The Secretary of the Navy says no more beer or liquor for the navy. Even their ladies cannot have a "stick" in their pink tea. (One minute, please, while we change the reel.) Next go for tobacco-users. Once we knew a navy man who smoked and he died an orphan at 92, with no one to advise him. If he hadn't smoked he might have lived to be 70—and died when he was of more use.

⁂

A some keen Frenchman, one Talleyrand, once remarked that language was an instrument for concealing thought. This gem scintillates most brightly in a legislative bill for the water-power rights gobbler, or in an act aimed at a rival lighting company to hit its competitors. Reduced to a common figure, it's a "joker."

⁂

While the suffragetters can't go back to Hero, like us, there are records of them in Denmark, in 1722. Sille Gad is the name of one of the original settlers. Do you suppose that these two Danish words can be translated literally into English?

⁂

Sure hope you glimpsed a modest personal about William T. Travers in the Apr. 7 issue. Mr. Travers served 44 years as engineer of Brooklyn's Prospect Park pumping station. Know any engineer who can equal this record? If so, let's have his name that we may do him proud.

⁂

Waxing facetious over King George's recent fireplace invention, "Engineering News" says that in view of late developments in British politics, it may be a good thing to have a trade to fall back on. Don't you mind 'em, friend King. You stick to "Power;" there's lots of good openings for a fireplace man over here, so if the worst is yet to come, just drop us a line.

Wilson-Snyder Centrifugal Pump

This pump is designed along new lines with the purpose of minimizing leakage, to prevent the leakage current from disturbing the main flow of the fluid entering the impellers of the pump, and to properly direct the flow of the liquid into the impellers. Attention has also been given to the reduction of friction at the tightening joints by avoiding contact between the fixed and rotating parts.

Three points of main importance have been considered by the designer. The first one is that the direction and

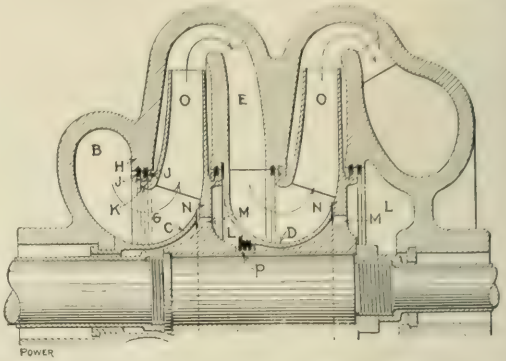


Fig. 1. Sectional View through Wilson-Snyder Centrifugal Pump

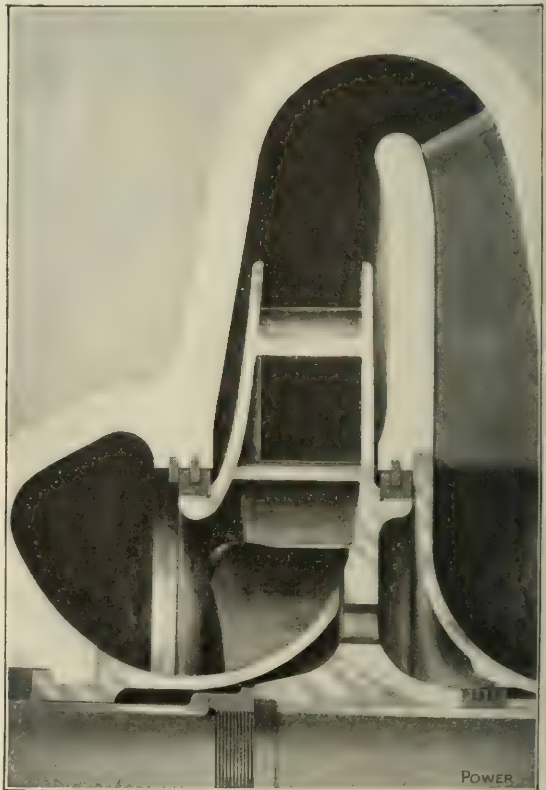


Fig. 2. Enlarged Section of Impeller and Tightening Box

the velocity of the liquid at the point of contact with the first element *A*, Fig. 1, of the vanes, or vane inlet, are fundamental factors in the calculation and delineation of the shape of the vanes. If, then, anything occurs to deviate the direction and change the velocity of the liquid at the vane inlet, the performance of the pump will be different from what was intended. The second point is that as the liquid leaves the impeller, nothing can add to the energy it possesses, and every surface with which it comes in contact will cause a reduction of energy, the delivery must, therefore, be well proportioned and made very smooth. The third point concerns the conservation of the energy generated by the impeller, and, consequently, the prevention of the cause of loss of that energy through leakage at the running joints The design of this pump seems to cover these three points.

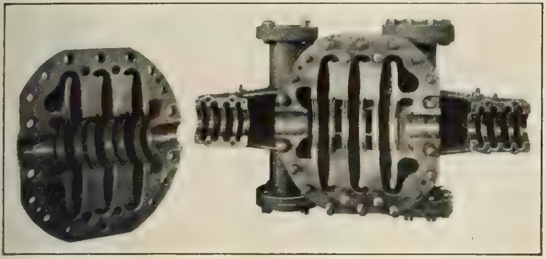


Fig. 3. Internal View of Pump Casing

Referring to Fig. 1, the inlet water enters the pump casing through the passage *B*, and follows the removable conoidal guide shell *C*, which surrounds part of the hub of the first impeller, the shaft and its protecting sleeve *D*. The guide shell is so designed that when fitted in place it does not come in contact with the rotating members of the pump and forms an effective guide for the liquid from the intake chamber *B* to a point close to the vane inlet *A*. A conoidal guide shell *D* surrounds the hub of the second impeller and acts as a guide for the liquid from the passage *E* to the vane *F* of the second impeller. This arrangement of the guide shells causes the incoming liquid to flow smoothly into the impellers and prevents the said liquid from coming in contact with the surface of the rotating parts until it has rached the vane inlet. Thus the incoming water engages the impeller vanes while in an undisturbed state and in the direction originally adopted by the designer as one of the data upon which the calculation for the impeller are established.

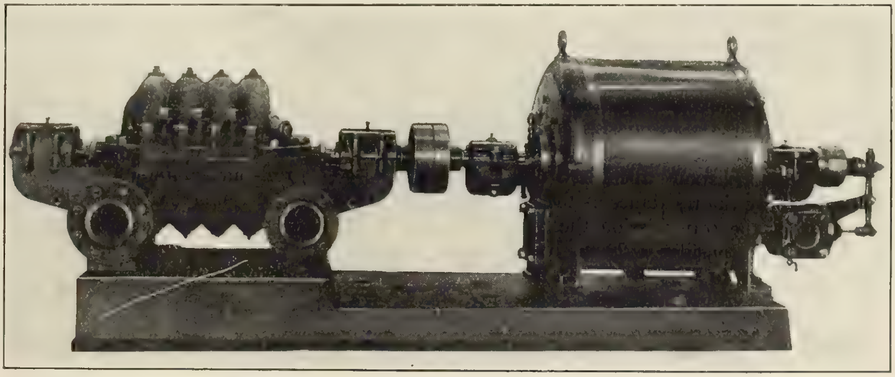


Fig. 4. General View of Wilson-Snyder Turbine-Driven Pump

Upon discharging from the impeller the water, then under pressure, tends to flow past the impeller into the inlet chamber *G*, but is prevented by a tightening running joint between the casing wall *H* and the inlet flange of the impeller. This joint is composed of the four annular flanges *J*. The lower flanges are separately mounted on the external wall of the impeller-inlet flange *K*. The two upper flanges are each inserted into the wall *H*, which surrounds the entire tightening device. A slight lateral clearance, just sufficient to avoid rubbing contact and to allow free running of the rotating parts is provided; the clearance is maintained by a thrust bearing of the marine type connected to the exterior of the pump casing.

Any liquid passing the tightening joint mingles with that in the main flow without appreciably disturbing it on its way to the inlet *A*.

On the rear of each impeller is a balancing chamber *L*, the pressure of which is substantially equal to that in the preceding inlet chamber, as communication is provided through the hub *N*. The liquid under pressure tends to flow from the impeller chamber *O* to the balancing chamber, but it is intercepted by a tightening device, similar to that already described. A multiflange-ring-tightening device *P*, which acts the same as the other tightening devices, is attached to the shaft and under side of the guide shell *D*. The leakage of liquid past this tightening device and the one at the rear of the impeller tends to maintain, in the balancing chamber *L*, a pressure greater than that obtained in the preceding inlet chamber, but the liquid escapes through the hole *M* and, following a narrow passage formed between the end of the guide shell *C* and *D* and the impeller hub, is directed substantially tangentially with and into the liquid current passing from the inlet chamber proper into the inlet *A*.

In Fig. 2 is shown an enlarged section of an impeller and the tightening boxes Fig. 3 is a view of the pump casing. A general exterior view of a steam turbine-driven pump is shown in Fig. 4.

This pump is manufactured in sizes varying from 2 to 24 in., both for single-stage double-suction and multi-stage types by the Wilson-Snyder Centrifugal Pump Co., 2 Ross St., Pittsburgh, Penn.

High-Head Water Power—A French company will build in the Canton of Wallis, in Switzerland, a water-power plant, which will have a head of 165 atmospheres, nearly 2500 lb., or 5000 ft. The velocity with which water would be discharged under this head is something like 560 ft. per second, and considerable interest will attach to the type of turbine, which will be used to utilize such a head. It is said that these turbines will be manufactured by a firm in Geneva (probably Piccard Pictet & Co.), while the pipe, which is some 15,500 ft. long, and which requires to be 1¾ in. in thickness at the lower end, will be made by a German firm.

Transmission of Heat through Building Materials

By Frank L. Busey

Since the heating capacity required for a building depends on the amount of the heat losses, it follows that the first step in laying out a heating system is to make a thorough study of the building construction used, and to determine the extent of these losses.

Books giving data on heating contain tables of coefficients, from which one may select factors for the kind of construction which is to be provided for. These coefficients give the heat loss or transmission in B.t.u. per square foot per hour per degree difference in temperature of air on opposite sides of the material. Some of the commonly accepted factors will be found in the accompanying tables. Such factors are fairly reliable when applied to building constructions listed in the tables, but when one is called upon to figure the loss through a wall of a different thickness, or composed of a variety of materials, there is a chance for some tall guessing.

The theory of heat transmission as announced by Peclet has been generally accepted by engineers, and will be found in Professor Carpenter's "Heating and Ventilating Bulidings." According to this theory, the heat transmission from a wall consists of three parts: Radiation and convection from the warm room to the inner surface of the wall; conduction through the material itself; and lastly, radiation and convection from the outer surface. That is, the transmission is due to the two components, radiation and conduction. Although sometimes stated to the contrary, it is evident that a wall of twice the thickness will not have a factor just one-half as great, since the surface loss is the same in each case, and only the loss by conduction is decreased. This part of the total loss (the conduction) does vary inversely as the thickness of the material, but that portion of the heat loss due to radiation from the surface remains the same, no matter how much the thickness is increased.

We are accustomed to think of a wall as transmitting heat, but one may consider the reverse function, viz., its resistance to the transmission of heat. Every form of building construction offers a certain resistance, and the greater this resistance the less will be the transmission. Thus we have the resistance as the reciprocal of the transmission, or the transmission the reciprocal of the resistance. If we consider a 21-in. brick wall with a transmission equal to 0.22 B.t.u. per square foot of surface per hour per degree difference in temperature between the two sides, the resistance of this wall will be

$$1 \div 0.22 = 4.55$$

If we state that the resistance of 2 in. of concrete is 0.80, then the transmission is

$$1 \div 0.8 = 1.25 \textit{ B.t.u.}$$

This relation between resistance and transmission holds true both for the conduction and the radiation factors.

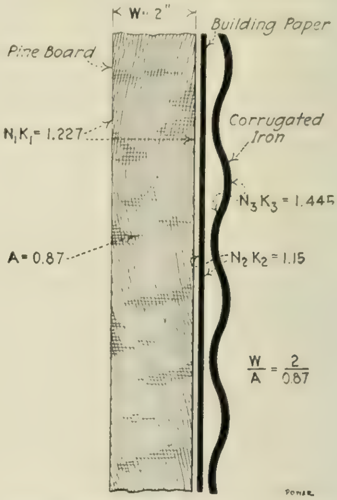
In determining the transmission or heat loss from a wall composed of various substances whose factors are known, it is not correct to add the transmission factors for each substance and call the sum the total transmission of the composite wall, but rather we should find the sum of the resistances of each substance, and the reciprocal will be the factor desired. That is, the factor is the reciprocal of the sum of the reciprocals of the transmission factors of each substance. For example, let us be required to find the proper coefficient for a wall composed of a single thickness of 2-in. pine boards covered with corrugated iron. From the tables of heat transmission we note that the factor for 2-in. board is 0.35, and the reciprocal, i.e., the resistance, is 2.86; and that the factor for corrugated iron is 1.50 and its reciprocal is 0.67. Then

$$2.86 + 0.67 = 3.53$$

is the resistance of the wall and the heat transmission will be

$$1 \div 3.53 = 0.283 \textit{ B.t.u.}$$

per square foot per hour per degree difference in temperature between the two sides of the wall. This might be reduced perhaps 10 per cent. to allow for the extra resistance offered by the small air spaces between the board and the corrugated iron. A factor commonly used for this construction is 0.26 B.t.u.



Heat-Transmission Coefficients

The discrepancies between the coefficients given by different authorities are generally attributable to the fact that the values quoted have been determined for different conditions. While the conduction factor depends only upon the thickness of the material, the radiation factor is subject to a number of influences, such as the height of a wall; whether in a horizontal or vertical plane; the difference between the temperatures of its opposite sides and the velocity of air over the surfaces. Thus we see that it makes a difference whether the material is in a side wall or a ceiling; an inside or an outside wall; or whether the surfaces are swept by air currents. While for greater accuracy, especially in cold-storage work, all of these variables should be considered, in ordinary heating work, we may assume that the ordinary coefficients will meet the average conditions.

As mentioned in POWER of Nov. 11, 1913, an elaborate testing plant has been installed at the Pennsylvania State College for determining the effect of these various influences on the rate of transmission. In the article referred to, Professor Moyer shows that in the case of a cork-board cube, by increasing the velocity of the air currents over the surface from 222 to 905 ft. per min., the rate of transmission was increased about 34 per cent. This means a difference of 5 per cent. in the transmission per 100 ft. per min. change in air velocity. The tests reported showed also that an increase of 10 per cent. in humidity caused an increase of 1.2 per cent. in the transmission.

The values of temperature factors N, given in Table 1, for use in connection with the coefficients of transmission will be found to agree substantially with those quoted by leading authorities. The values are based on the assumption that the coefficients given are for a temperature difference of 70 deg. and will decrease or increase correspondingly for a decrease or increase in the temperature difference. This factor N should be applied to the surface or radiation coefficient, and not to that for conduction.

TABLE I. VALUES OF N

For Various Temperature Difference

Difference Between Inside and Outside Temperature	N	Difference Between Inside and Outside Temperature	N
5	0.573	50	0.945
10	0.661	55	0.963
15	0.730	60	0.975
20	0.780	65	0.988
25	0.815	70	1.000
30	0.849	75	1.010
35	0.875	80	1.020
40	0.900	85	1.028
45	0.924	90	1.033

It will perhaps assist in making the foregoing more easily understood if we use a series of equations to show the relation between the various factors mentioned, employing the following symbols to represent the various factors and coefficients.

N = Temperature factor to be applied to the coefficient for surface radiation, the values to be taken from the accompanying table;

NK = Surface transmission for each material;

$\frac{1}{NK}$ = Surface resistance to the transmission of heat by radiation and convection.

The conductivity of any material will vary with the thickness, so that we will have

A = Conductivity of material itself from surface to surface per unit thickness;

$\frac{1}{A}$ = Resistance of the material per unit of thickness to the transmission of heat;

W = Thickness of the material;

$\frac{A}{W}$ = Conductivity of the material;

$\frac{W}{A}$ = Resistance of the material to conduction;

L = B.t.u. transmitted per sq.ft. per hour per deg. difference in temperature between the two sides.

The transmission being the reciprocal of the resistance, then the greater the resistance, the less the heat transmitted, and as the total resistance is composed of the two factors $\frac{1}{NK}$ and $\frac{W}{A}$, we have the transmission in B.t.u. per square foot per degree difference in temperature between the two sides of the material stated by the equation:

$$L = \frac{1}{\frac{1}{NK} + \frac{W}{A}}$$

and the total transmission per square foot per hour with temperatures t_1 and t_2 on the two sides of the material will be

$$L_t = \frac{(t_1 - t_2)}{\frac{1}{NK} + \frac{W}{A}} = L\,(t_1 - t_2)$$

In case we are to consider a double wall or a wall made of more than one material, we will have greater resistance due to the extra surfaces adding their resistance and also to the added resistance to conduction, thus giving a lower rate of heat transmission. This will then give us

$$L = \frac{1}{\left(\frac{1}{N_1 K_1} + \frac{1}{N_2 K_2} + etc.\right) + \left(\frac{W_1}{A_1} + \frac{W_2}{A_2} + etc.\right)}$$

In case the materials considered are very thin, but slight error will be introduced if we neglect the conduction factor and consider only the resistance of the surface. Table 2 gives values for K and A for use in the above equations, and will be found to cover many of the more common forms of building construction.

TABLE 2. VALUES OF K AND A FOR DIFFERENT MATERIALS

Materials	K	A
Brick	1.275	5.50
Brick and 2-in. air space	0.460	5.50
Pine board	1.275	0.97
Oak board	1.275	1.75
Double pine, paper between	0.475	0.97
Sheet iron	1.200	....
Corrugated iron	1.500	....
Pine board and corrugated iron	0.575	0.97
Pine board and sheet iron	0.675	0.97
Single glass	1.095	7.2
Double glass	0.470	....

The application of the foregoing formula may best be shown by a practical example, in which it is required to determine the coefficient of the transmission per square foot per degree difference in temperature for a wall composed of 2-in. pine boards covered with building paper and corrugated iron, with a difference of 55 deg. in temperature between the two sides. From Table 1 we find the value of N to be 0.963.

We will have six surface resistances to consider, NK for the two surfaces of the board being $0.963 \times 1.275 = 1.227$ and for the two surfaces of the corrugated iron, $0.963 \times 1.5 = 1.445$. As the paper and the iron are quite thin, the resistance to conduction would be small and may be omitted for these two materials without serious error.

We will then have the surface resistance $\frac{1}{N_1 K_1} = \frac{1}{1.227}$ for the two board surfaces, and assuming the same surface loss for paper as is given for sheet iron, we will have the resistance for the two sides of the paper $\frac{1}{N_2 K_2} = \frac{1}{1.15}$. As already stated, the resistance of the two surfaces of the iron will be $\frac{1}{N_3 K_3} = \frac{1}{1.445}$. The resistance to conduction of the 2-in. pine board will be $\frac{W}{A} =$

$\frac{2}{0.97}$. Then we will have the total transmission in B.t.u. per square foot per degree difference in temperature between the two sides of the wall as.

$$L = \frac{1}{\frac{1}{1.227} + \frac{1}{1.15} + \frac{1}{1.445} + \frac{2}{0.97}} = 0.224 \textit{ B.t.u. per}$$

hour per square foot

TABLE 3 HEAT LOSS FROM BUILDINGS

B.t.u. Transmitted per Hour per Square Foot of Surface per Degree Difference in Temperature

For Various Wall Constructions

Thickness of Board, In	Pine Board	Double Board, Paper Between	Board and Corrugated Iron	Board and Sheet Iron
½	0.77	0.32	0.45	0.50
1	0.51	0.24	0.36	0.40
1½	0.43	0.19	0.30	0.33
2	0.35	0.16	0.26	0.28
2½	0.30	0.14	0.23	0.25

Constants for Brick Walls

Thickness, In	Plain	Plastered One Side	Air Space and Plastered	Furred and Plastered
8½	0.37	0.36	0.25	0.23
13	0.29	0.28	0.21	0.20
17½	0.25	0.24	0.19	0.18
22	0.22	0.21	0.16	0.16

For concrete walls add 25 per cent. to the above values for brick

The values given in Table 3 serve to show how the coefficients for various combinations may be determined, and a table compiled covering any special constructions commonly used.

For cold-storage work the values given in Table 4 will be found convenient, since the factors for resistance and transmission are both given. These factors are based on the results of tests as published by the Armstrong Cork Co. The values quoted for brick and the various materials tabulated down to "hollow tile" are for separate thicknesses of 1 to 6 in. and the values for the rest are for the usual dimensions of the materials referred to.

By the use of the resistance factors, the transmission for various wall combinations may readily be determined. For example, what will be the coefficient of transmission for a wall consisting of 4-in. brick; 2-in. ground cork, and 1-in. concrete? From the table we see that the resistance factors for the above materials are 1.60, 3.49 and 0.667 respectively, and the resistance of the wall will be the sum of the above, or 5.757. The transmission factor will then be

$$1 \div 5.757 = 0.173 \textit{ B.t.u.}$$

per sq.ft. per hour per degree difference in temperature between the two sides. This should be increased perhaps 10 per cent. in case of an outside wall exposed to the direct rays of the sun.

TABLE 4. RESISTANCE AND TRANSMISSION OF VARIOUS MATERIALS

B.t.u. per Hour per Sq.Ft. per Degree Temp. Difference

Resistance $\frac{1}{L} = \frac{1}{K} + \frac{W}{A}$ Transmission $L = \frac{1}{\frac{1}{K} + \frac{W}{A}}$

Material	Resistance: Thickness of Material—Inches					Transmission: Thickness of Material—Inches				
	1	2	3	4	6	1	2	3	4	6
Brick	1.00	1.20	1.40	1.60	2.000	1.000	0.835	0.715	0.625	0.500
Concrete	0.667	0.80	0.935	1.07	1.335	1.500	1.250	1.070	0.940	0.750
Pine board	1.83	2.86	3.89	4.92	6.990	0.545	0.350	0.257	0.203	0.143
Ground cork	2.09	3.49	5.00	6.30	9.020	0.479	0.286	0.200	0.159	0.112
Nonp. cork-board	3.85	6.90	9.95	13.00	19.100	0.260	0.145	0.100	0.078	0.052
Ind. fibre-board	2.40	4.02	5.62	7.23	10.44	0.416	0.249	0.178	0.138	0.096
Hair felt	3.23	5.80	8.37	10.25	16.07	0.310	0.172	0.119	0.098	0.062
Mineral wool	1.50	2.07	2.77	3.47	4.87	0.666	0.483	0.361	0.288	0.205
Saw dust	2.63	4.60	6.57	8.52	12.42	0.380	0.218	0.152	0.117	0.081
Hollow tile:										
2 to 6 in.			1.60					0.625		
8 to 12 in.			2.78					0.360		
Air space 1 to 6 in.			0.60					1.66		
Corrugated iron			0.67					1.50		
Sheet iron			0.80					1.20		
Building paper			0.50					2.00		
Tar and gravel			0.50					2.00		
½" slag			0.60					1.67		
½" cement			0.77					1.30		

Building a Smokeless Furnace

By F. A. Shoemaker

The article on this subject, by E. E. Clock, in the issue of Feb. 3, was interesting. The device described was used in the early part of the 80's by Martin, an engineer in Chicago. About two years ago the manager of a local malt-drying corporation claimed his company had recently come into the ownership of a patent covering the same device except that in both of the above cases the three small ducts beneath the grates through the bridge-wall were not used.

I tried the honeycomb wall on top of the bridge-wall some years ago and with careful firing little smoke was produced after the wall became nearly white hot, but it took time each morning to get the wall hot enough to cause perfect combustion. In the meantime, it seemed that before the wall was sufficiently heated there was more smoke than usual without any wall of the kind; besides, the boiler-insurance companies objected on the ground that an 18-in. wall coming in close proximity to the underside of the boiler shell might damage the boiler, particularly at the time of washing out, owing to the heated condition of the wall.

I find it much better to set the boiler at least 36 in. above the grates. I do not carry the bridge-wall more than 14 in. above the grate surface and extend it straight across the furnace. The object is to keep the shell away from the fuel so that when using long-flame bituminous coal, complete combustion will take place before the flame strikes the shell.

The main source of smoke or incomplete combustion is chiefly attributable to a lack of proper knowledge and in many cases to carelessness on the part of the firemen. To get the highest efficiency and to produce the least amount of smoke from any bituminous coal the firemen should be compelled to keep as clean a grate surface as possible as well as a clean ashpit, keep the grates covered at all times with a live open bed of fuel which is not too thick. The class of fuel and its steam-producing qualities will readily determine the thickness of the fire.

It has been found that an almost smokeless result can be obtained with any reasonable high setting if the firemen will follow the above suggestions together with a method of firing something on the following order:

Never place more than two shovelfuls of coal on the fire at a time under running conditions, spreading the two shovelfuls over the rear left-hand quarter of the grate surface and closing the door quickly. At the next firing place a like amount on the front right quarter, following this by a firing on the front left quarter and the next firing on the rear right quarter, always being careful to leave no holes in the fire or piles of unburned fuel. By taking care to fire this way, giving the fuel an ample amount of air from beneath the grates, it will not only be found that the saving in fuel is in many cases greater than the fireman's wages for a given period, but much better regulation of the steam pressure can be had and little trouble will be experienced in removing soot from the flues. This method applies to the ordinary setting of fire-tube shell boilers in the usual factory plant where the manager is the owner, who, from his multiplicity of other duties, gives very little attention to how the coal is being used, except from the fact that the coal bills always appear to be too high for the amount of power and heat received.

Much of the money that is now spent for fuel could be saved and the smoke nuisance abated if the owner and the fireman would get together and make an arrangement that the fireman was to first keep up a steady, even gage pressure at all times and secondly to share a certain percentage of the fuel saving he could make over the present careless methods. This would give the fireman an incentive to learn his business more thoroughly and treat the coal pile as if it were something paid for by himself and must be handled to the best possible advantage, and to add to these results I have found that the following described setting where the stack or chimney has a reasonable amount of draft makes it possible to operate a boiler with almost no visible sign of smoke from the stack at any time.

One method I have used to prevent smoke is to run three or more small air ducts behind the firebrick lining of the inside walls of the furnace with openings so that the air can enter these ducts just beneath the grate surface, and open the outlet of the air ducts in the side walls to a level with the lowest portion of the boiler shell. The openings in the wall are 4 in. long by 2 in. wide with a 4x4-in. intake beneath the grates and a 1½x4-in. opening where the air enters the furnace compartment.

[Some engineers will, perhaps, disagree with Mr. Shoemaker as to the advisability of a setting having air channels built in the walls to connect the combustion space with the ashpit. We should be pleased to have the subject discussed by those qualified.—EDITOR.]

I had this system installed in one of the largest department stores in Buffalo some years ago with the boilers set 3 ft. 6 in. above the grates. The plant previously burned 100 tons of anthracite egg coal per month, costing $5.55 per ton. Since the installation of this device and with reasonably good firing, the plant has never used over 75 tons per month of bituminous slack coal at about $2.30 per ton, and there is never any perceptible smoke from the stack, except when starting a new fire after cleaning one or the other of the 200-hp. return-flue boilers. With hard coal the engineers were obliged to run both boilers in cold weather, but since using soft coal with this device they never use both boilers at the same time.

The principle of this method is to have a slight blanket of highly heated air in contact with the boiler shell above the fire and bridge-wall, and keep the flame from striking the shell.

This plant has operated under the above conditions for the past five years, the boilers being used for heating and cooking purposes, and the saving in coal bills has been not less than $700 per year and as soon as hard coal went up to $6 and over in this city the saving has been increased over that amount.

The cost of placing these ducts in the furnace walls was less than $100, so it can be readily seen that from the cost of investment compared with money saved by their use that they are a profitable investment.

The question of making tests to ascertain the efficiency of the fuel has been suggested to parties using this method, but they have objected to either having or permitting any tests being made, stating as their reasons that the saving in fuel cost over the old method has given them sufficient record of what is being done and they do not care to have an efficiency test run.

It is strange that after so many years of power-plant engineering, mechanical engineers find it hard to convince the owners of boilers that, by a small investment at the start, they can eliminate smoke and get much higher efficiency from their power plants, having the original investment returned to them many times. The fact is it takes so much time to convince a client of this fact that the returns to the engineer are unprofitable, but still we keep at it, hoping some day to convince a sufficient number of power-plant owners so that the others will appreciate the value of high settings and need no elaborate proposals to convince them that they should use such settings.

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The Cost of Power-Plant Equipment and Supplies

Data bearing upon the cost of power-plant apparatus, supplies and construction materials are often useful to engineers who are obliged from time to time to prepare estimates of the expenses of plant extensions, new construction or alterations. Some material of this character is presented in the following tabulation, the costs being obtained from a Massachusetts steam-driven station, supplying electricity to a population of about 100,000 people. The costs printed are accurate, although they are necessarily rather miscellaneous, as only those items have been given which are likely to be useful in the preparation of estimates. Many small supplies are included, but the engineer who desires to make use of the figures will have no difficulty in classifying them or transferring them to card indices as desired.

REPRESENTATIVE POWER-PLANT EQUIPMENT COSTS

Four stokers for four 400-hp. Porcupine boilers, Murphy Iron Works	$6,900.00
Four 400-hp. Porcupine boilers with 52-in. stacks	20,700.00
Brick setting for above stokers and firebox	2,000.00
One 4500-kw. Parsons turbine, including exciter, priming pump and Le Blanc condenser, Westinghouse Electric & Manufacturing Co	45,000.00
Fifty direct-current, 5-amp., constant-series, inclosed arc lamps, General Electric Co	1,125.00
Fifty electrodes for above type of lamps	3.00
One 10,000-volt, Weston dial voltmeter, complete, for arc service	268.38
One special 5-amp., 75-light, 60-cycle, form BWZ, General Electric Co., combined unit-mercury arc-rectifier outfit, with cylinder and transil oil (50 gals. No. 6 latter), one switchboard panel, lightning arrester and iron drum	1,777.65
Six extra rectifier tubes	120.00
Two No. 70 Ward, Drouet & Foster potheads	16.55
Two hundred bricks	1.45
Three 100-amp., 5500-volt, Condit oil switches and fittings	91.20
One barrel of grease	18.80
One 75-k.v.a., 60-cycle, 440-volt Westinghouse transformer, oil and hanger irons	360.00
One 100-amp., 2500-volt Condit circuit-breaker	27.95

Three hundred and fifteen feet 2x12-in. spruce boards	9.90
One hundred and forty-four gallons "Minerallac"	142.80
Forty-eight feet 6x8-in. spruce boards	1.34
Two ⅝x12-in. machine bolts	0.15
Ninety-seven feet 4-in. express lumber	16.76
One bag asbestos cement	1.75
One barrel hard grease	21.00
One thousand brick	10.00
Two 75-amp. 110-volt General Electric Co. meters	38.03
Two 100-amp. 220-volt, 60-cycle, General Electric Co. type "I" meter	75.60
Twenty-five 5-amp. 110-volt meters	253.13
One 14-in. Lagonda strainer	440.00
One 20-in. Lagonda strainer	660.00
One hundred 1x6-in. machine bolts	10.20
One 10-in. angle valve, Star Brass Manufacturing Co	162.00
Four 2½-in. brass globe valves, Star Brass Manufacturing Co	138.00
Twenty-five bags cement	11.25
One hundred and twenty square feet asbestos wood, for switchboard work	19.20
Fifty switchboard card holders	26.00
One 1½-in. Watson-Stillman "Levo" pump, 60-cycle, 220-volt Wagner motor	210.00
One Bristol recording thermometer	107.20
One Catchall (Hohmann & Maurer) vacuum gage	85.00
One hundred feet ½-in. iron pipe	4.10
Two hundred and twelve feet 6-in. iron pipe and six ells	5.76
One 7-in. Chapman iron gate valve	16.50
Two Argand steam blowers	79.55
One hundred 1x⅜-in. machine bolts	0.60
One hundred and ten ft. ½-in. tiller rope	10.01
Forty feet ½-in. hoisting cable	2.04
One General Electric Co. steam-flow meter, size not stated	75.00
Eight bars 2x2x¼-in. angle iron	10.00

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International Engineering Congress, 1915

The attention of the engineers of the world is being more and more drawn to the program of the International Engineering Congress to be held in San Francisco in 1915. The interest aroused in foreign countries is shown by the fact that at the present time there have been received enrollments and subscriptions from 42 countries. Furthermore, the present total enrollment, approximately 25 per cent. is from countries other than the United States. The number of subscriptions from the members of the five national engineering societies of the United States is, however, not so gratifying. The percentage of the total membership represented by the subscription list is only 3.7, and this, although each individual member has received circular information and data concerning the Congress and has been urged to send in his subscription promptly.

It is probable that this is largely because the Congress is still somewhat in the future, and also to the tendency of the individual to procrastinate. This, to a considerable degree, handicaps the work of the committee on management, and it is extremely desirable that as many as possible who intend to subscribe should do so at an early date.

The list of topics to be treated in the section on mechanical engineering gives a very good idea of the character of the publications which it is intended to issue. These are as follows:

Recent progress and present status of foundry practice, and casting metals; Recent progress and present status of the art of forging; Equipment processes, and methods for the boiler shop; Machine-shop equipment, methods, and processes; Automatics; Special processes for shaping and forming metals; High temperature flames in metal working; Industrial management; Safety engineering; Industrial museums as an educational factor; The steam engine of the year 1915; The steam turbine of the year 1915; The internal-combustion engine of the year 1915; Motors of the Diesel type; The Humphreys gas pump; The steam boiler of the year 1915; Refrigeration; Pneumatics; Lubrication and lubricants; Waterwheels of pressure type; Waterwheels of impulse type; Hydraulic power developments and use; Power-plant design; Motor vehicles, passenger type; Motor vehicles, utility type; Motor tractors.

Many of these topics will be treated as symposiums with contributions representing the practice in more than one country.

The various sections outlined for the work of the Congress and the volumes to be issued are as follows:

Vol. I, The Panama Canal; Vol. II, Waterways and Irrigation; Vol. III, Municipal Engineering; Vol. IV, Railways and Railway Engineering; Vol. V, Materials of Engineering Construction; Vol. VI, Mechanical Engineering; VII, Electrical and Mechanical Engineering; Vol. VIII, Mining Engineering and Metallurgy; Vol. IX, Naval Architecture and Marine Engineering; Vol. X, Military Engineering, and Miscellaneous.

Vol. X will consist only in part of Military Engineering, and will also contain papers on miscellaneous topics which are not definitely associated with any of the various sections. Full information concerning the congress may be obtained by addressing the International Engineering Congress, 1915, Foxcroft Building, San Francisco, Calif.

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New England Association of Commercial Engineers

The New England Association of Commercial Engineers was organized at Worcester, Mass., July 12, 1911. It is an association of individuals to which are eligible business men, inclusive of executives, officials and salesmen affiliated commercially with power-plant engineering in New England. From 47 charter members the membership has grown until, at present there are 214, representing some 180 business firms.

One of its principal objects is to bring together representatives of different industries in the power field and devise ways and means of increasing the business of the engineering lines in New England. Association is always helpful, and the members have found that by becoming acquainted with each other it has resulted to their mutual benefit. Although competitors in the same line of apparatus are brought into social contact, and competition is as keen as ever, it is on a cleaner and more wholesome basis.

Another object is to bring the users and the selling end of power-plant equipment and machinery more closely together, and to obtain more consideration for the commercial engineer who represents the selling end. The members have the opportunity, which they do not neglect, of helping the operating engineer in working out problems which are up for solution, by volunteering information on the line in which he is interested.

There is another way in which the members are benefited. In the routine of business a member is bound to hear of the proposed installation of some device or machine which is handled by another member. The logical thing to do is to notify the former of the prospective new business, and to advise the prospective purchaser of the name of the member and the firm he represents, who handles the particular apparatus desired. This also helps the engineer in getting in touch quickly with the firm which can supply his requirements. This coöperation offers an opportunity to do away with friction, which retards progress in any line of endeavor, eliminates prejudice and opposition and helps to overcome obstacles which stand in the way of business progress.

The commercial engineers realized early in their career that the facilities for getting business must be given attention, and from the first set about conducting a power show, where it was possible to meet those who were interested in power-plant apparatus. The first show was held in Mechanics' Building, Boston, during one week of April, 1912, when over 125 manufacturers of power-producing machinery, specialties, supplies and accessories were represented, and when thousands of engineers and others interested in power-producing mechanics visited the exhibits.

A second show was held in Northampton, July, 1912, in connection with the Massachusetts Association of Stationary Engineers' state convention, when about 70 exhibitors displayed their products.

As another means of getting in touch with new business, a news bureau was established on June 3, 1912, with 25 members. Members of the association were privileged to contract for the news-bureau service by paying $1 a week. The bureau furnishes clippings from 40 to 50 local daily newspapers published in New England from government bulletins and foreign trade reports, and also keeps in touch with the offices of consulting and contracting engineers, architects and municipal building departments. News notes are also received through members of the association and from special correspondents stationed in New England. All information is transferred to a daily report sheet in letter form and mailed each day to the subscribers.

As a help to sustaining the coöperation feature of the organization, a monthly bulletin is published and monthly luncheon meetings are held. The bulletin is a four-page sheet in which are published business reports, notices and news notes, especially pertaining to the business matters of the association. At the luncheon meetings, when time permits, after transacting the business of the association, prominent men have been secured as speakers.

Another power show will be held in Mechanics' Building Apr. 27 to May 2, in connection with the Textile Exhibitors' Association's fourth national textile exhibition.

The power-show committee is headed by Claude D. Allen, which is an assurance that with the assistance of his able

Top row, left to right:
Wm. H. Walker, John D. Stiles.
Jas. W. H. Myrick, Claude D. Allen

W. Carlton Barnes, Vice-President

Bradford L. Ames
President

Herbert E. Stone, Secretary and Treasurer

Bottom row, left to right:
Wm. K. Campbell, John B. Harrington, John A Stitt, Albert C. Ashton

Officers and Directors of the New England Association of Commercial Engineers coöperators Messrs. Myrick and Warren, the coming exhibition will be most successful. The booths assigned to the association will be in the power department, convenient to all of the 150,000 and more spectators who are expected to attend.

For the benefit of those interested, the association has got out a business directory of members which not only gives the names of the officers, directors and members of the committees but also has a list of the members with their address and a directory of concerns and representatives.

The office of the association is in the Equitable Building, Boston, Mass. Bradford L. Ames is president, and Herbert E. Stone is acting secretary.

⁂

Old Employees Get Pensions

After long service the following employees have been retired and pensioned by the Consolidated Gas, Electric Light & Power Co., Baltimore, Md.: Robert Wright, 41 years' service; Robert J. Korr, 40 years; William H. Gallagher, 37 years; Jacob H. Griffin, 36 years, and John Rodgers, 21 years.

The system of retirement now employed by the Baltimore central station was planned by President J. E. Aldred and has been found to exert an excellent effect. The five men recently retired on pensions have been also put on the company's roll of honor and were recently presented silver medals in token of their long careers of usefulness and fidelity.

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Alabama Power Co. Installs First Unit

The Alabama Power Co., the principal operating company of the Alabama Traction, Light & Power Co., has completed the installation of the first of the four 17,500-hp. generating units at its hydro-electric plant on the Coosa River, at Lock 12. This unit is the largest of the single-runner type yet installed in a hydro-electric station and is the first of a 70,000-hp. development being made at Lock 12.

The construction of the dam makes a long stretch of the Coosa River navigable and it is estimated that the operation of the plant will save 500,000 tons of coal a year in the community.

⁂

Big Power-Plant Project Halted

In a decision reversing the opinion of the superior court of Skagit County, Wash., the supreme court of Olympia recently dismissed certain condemnation suits instituted by the Western Washington Power Co. against land owners along the Baker River and its tributaries. The court held that the testimony did not show sufficient cause for the exercise of the power to condemn private property for public purposes.

As a result of the decision, the plan to erect a big hydro-electric-power plant in Skagit County will be temporarily halted. The attorney for the Western Washington Power Co. will prepare a motion for a rehearing of the case by the supreme court. The testimony showed that it was planned by the power company to submerge several hundred acres of land by the erection of a dam 224 ft. high. The interest of the copartnership of Stone & Webster was shown in the evidence and not denied, but the supreme court held that the Western Washington Power Co. was organized to do by indirection what the copartnership could not legally accomplish under the laws of the state, relating to the right of condemnation of private lands.

ENGINEERING AFFAIRS

The Pittsburgh Association of the National Association of Stationary Engineers was shown the process of making tubing "From Ore to Finished Pipe" in the assembly room of the Fulton Building, Mar. 9, the lecturer being W. A. Phillips of the National Tube Co.

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W. A. Converse, chemical director for the Dearborn Chemical Co., recently completed a series of lectures on the subject, "The Ill Effects of Boiler Waters and Their Causes," before Eastern associations of the N. A. S. E. and the A. O. S. E. The places visited were Perth Amboy, Jersey City, Newark, Trenton, N. J., and New Haven, Hartford, Philadelphia, Baltimore and Reading, Penn.

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The American Society of Engineer Draftsmen and the Technical League of American have been consolidated as the Technical League of America. The officers of the consolidated Society are: President, Charles William Welch; secretary, Walter M. Smyth. The headquarters are at 74 Cortlandt St., New York City.

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The second International Congress of Consulting Engineers will take place in Bern (Switzerland) in 1914. At the first congress, which was held in 1913 on the occasion of the Universal Exhibition at Ghent, an International Federation of Consulting Engineers was founded for the purpose of uniting societies already in existence in a great number of countries; of assisting in the formation of similar organizations where none has yet been established and, finally to establish a bond which should prove extremely advantageous between consulting engineers throughout the entire world. The provisional program includes the survey of many subjects connected with the professional interests of consulting engineers. It is the purpose to hold the third congress in San Francisco in September, 1915, during the exposition.

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The "visitor's night," on Wednesday evening, Mar. 25, of the industrial arts department of the Ohio State University was most successful, about 1000 persons visiting the shops, largely mechanics. Invitations were sent through the shop superintendents, whose coöperation greatly helped in bringing the exhibition to their attention. The students were in the shops and engaged upon the work they ordinarily performed during the daytime. The object of the two-year industrial course taught by the university is to give the student a fundamental technical training under practical instructors. The first year includes elementary algebra; plane and solid geometry; trigonometry; freehand and mechanical drawing; lettering; pattern-making; forging; founding; bench work in metal. The second year, descriptive geometry; machine sketching; mechanical movements used in machines; elementary physics; strength of materials; machine-tool practice.

PERSONALS

Quincy A. Hall, formerly engineer of tests of the Isthmian Canal Commission, has associated himself with the Morgan T. Jones Co., Chicago, as secretary and engineer of tests. Mr. Hall is a graduate in mechanical engineering from the University of Illinois, and recently resigned his position with the Commission after over six years' service in the mechanical department.

O. P. Wilson, of the purchasing department of the Westinghouse Electric & Manufacturing Co., has resigned to become the assistant general manager of the Norma Company of America, 20-24 Vesey St., New York City, manufacturers and importers of ball bearings, precision instruments, etc. Mr. Wilson was with the Westinghouse Co. for 14 years and for the last ten years was one of its head buyers.

OBITUARY

KERAN GUNNING

Keran Gunning, a retired engineer, died of general debility on Friday, Apr. 12, at his home, 89 Walworth St., Brooklyn. He was 60 years old, and a member of the National Association of Stationary Engineers and the Brooklyn Veteran Firemen's Association. He leaves two sons and two daughters.

BOOKS RECEIVED

ENGINEERS' COSTS AND ECONOMICAL WORKSHOP PRODUCTION. By Dempster Smith and Philip C. N. Pickworth. Emmott & Co., Manchester, England. Cloth; 248 pages, 5½x8¾ in.; 32 illustrations; tables. Price, 4s. 6d.

GEAR CUTTING. By Joseph G. Horner. Emmott & Co., Manchester, England. Cloth; 391 pages, 5½x8¾ in.; 367 illustrations; tables. Price, 7s. 6d.

POWER

Vol. 39 NEW YORK, APRIL 28, 1914 No. 17

The Pity of It!

Warfare Halts Engineering Progress

"* * * As a result, the directors have unanimously decided to drop all further operations until the political disturbances affecting the company's works have ceased. Under the prevailing conditions it is impossible to transport to the dam the necessary supplies to complete the work. Practically the entire staff has therefore been released, retaining only a few men strictly necessary to safeguard the property. The dam has reached an elevation of 144 ft., and the reservoir is now filled with water to an elevation of nearly 121 ft. The power house is practically completed and much of the machinery installed."

—Extract from a recent news clipping.

Chicago Federal Building's Plant

By Thomas Wilson

SYNOPSIS—The addition of a 600-kw. generating plant to an equipment of boilers, elevators and compressed-air machinery effected a saving in operating expense of $1700 for the month of March. For the year, the saving should total over $14,000.

⁂

In these columns mention has been made of the decision to install in the Chicago Federal Building a generating plant to supply the current for light and power then furnished by the Commonwealth Edison Co. Since its inception in 1905, the building had been equipped with a boiler plant to supply steam for hydraulic elevator pumps, engine-driven air compressors serving a pneumatic tube system, for boiler-feed and other pumps and for the heating system. The exhaust from the units just mentioned only supplies about half the heat requirements of the building in the colder weather, so that a great deal of live steam was needed. The advantage of passing this steam through an engine cylinder before delivering it to the heating system was recognized, and the investigation was started which resulted in the installation of the present plant.

From the first month's operation, all expectations have been met and the results will be still better when the plant has been run long enough to be operated at its highest efficiency. For a total expenditure of $43,000, including an addition to the switchboard, steam piping and all new equipment, a saving has been effected in the operating expenses of fully $1700 for the month of March, as compared with last year's records. In the colder months this saving should be more, and in the summer months less, but a conservative estimate would be a gain of $12,000 to $15,000 per year, so that the generating plant will pay for itself in a period of three or four years.

Before taking up the records in detail it may be of interest to outline briefly the equipment of the plant. The building itself is of granite construction, covering in plan a city block. Part of it is three stories high; this increases to eight and then to sixteen stories at the center. The top of the dome is 360 ft. above the street level. The building has a total of 740,000 sq.ft. of floor space and houses practically 10,000 employees distributed be-

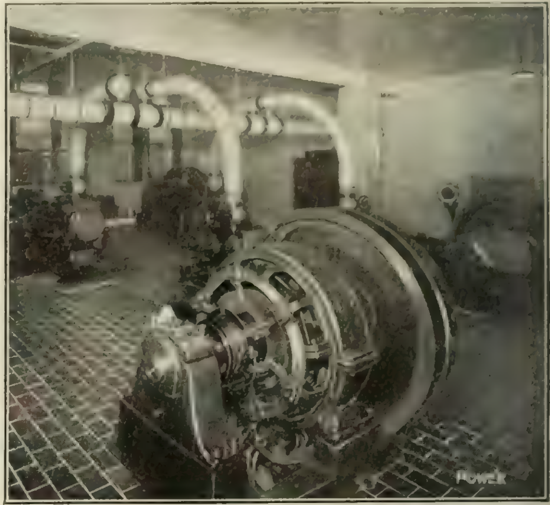

Fig. 2. The Four Generating Units

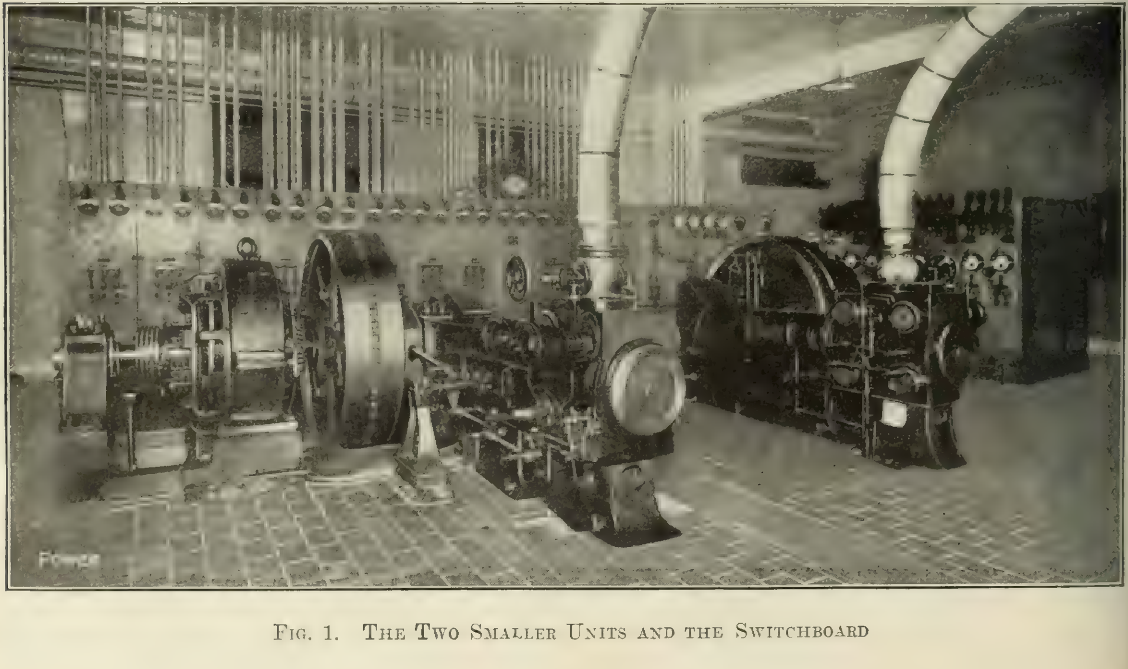

Fig. 1. The Two Smaller Units and the Switchboard

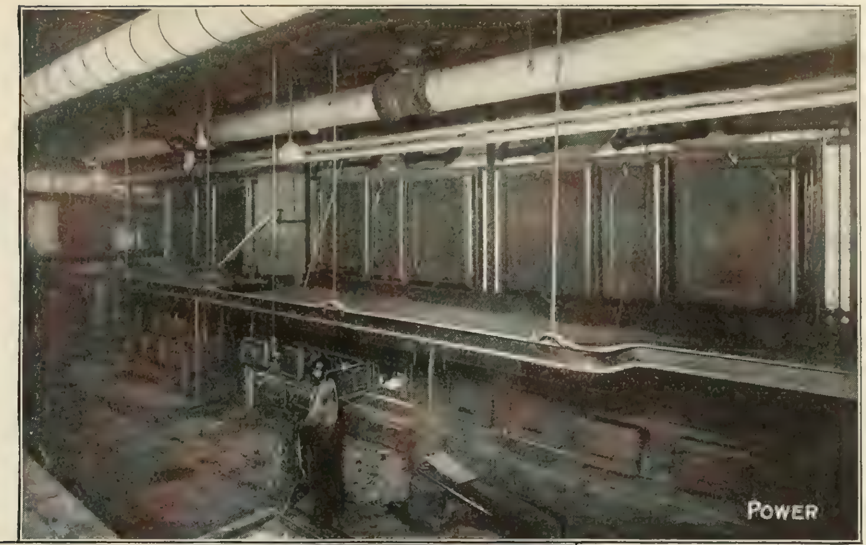

FIG. 3. THE FIVE 350-HP. BOILERS.

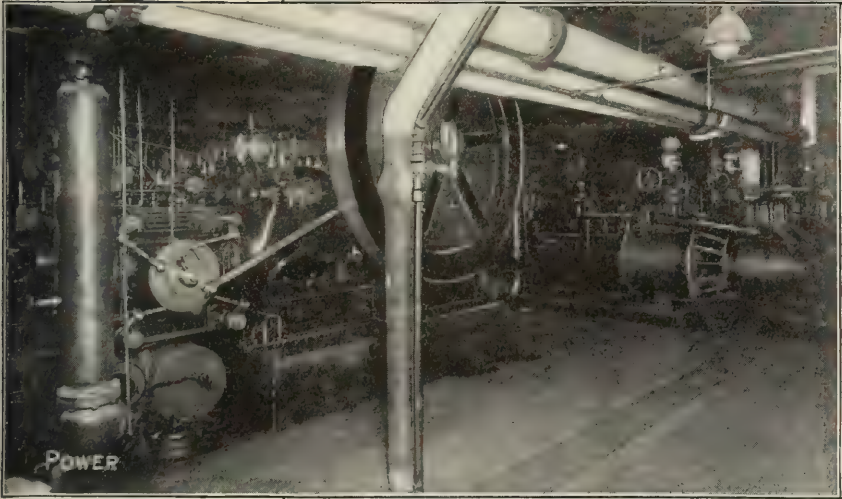

FIG. 4. THE THREE ELEVATOR PUMPS

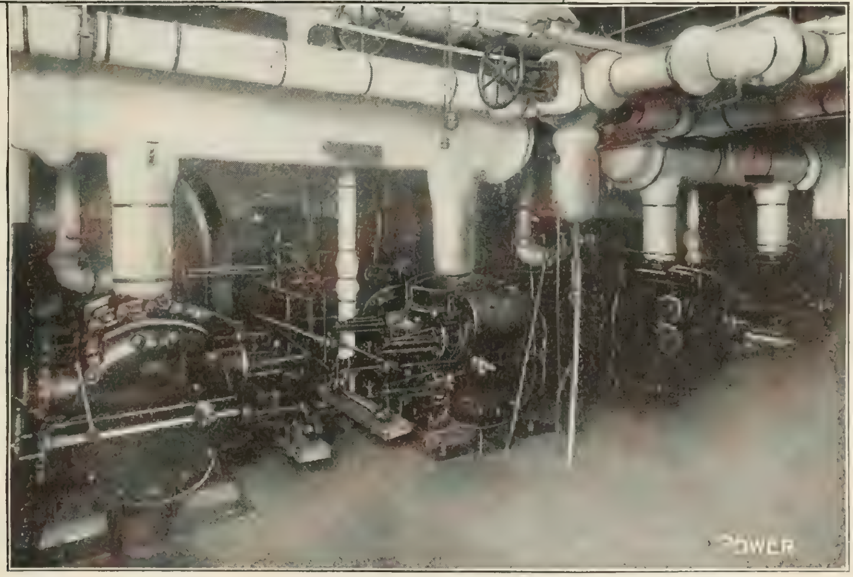

FIG. 5. TWO OF THE CROSS-COMPOUND COMPRESSOR UNITS

tween 15 departments. It is heated by 15,000 sq.ft. of indirect and 66,000 sq.ft. of direct radiation supplied with steam by a two-pipe Webster vacuum system equipped with three 10 and 16 by 12-in. vacuum pumps. The condensation is returned to a 900 gal. receiving tank, from which it is fed to a 5000-hp. Webster feed-water heater, then to a Green economizer provided with 144 four-inch tubes 12 ft. long, and finally to the boilers by two outside-packed plunger pumps, one 12 and 7 by 10 in. and the other 10 and 6 by 10 in. During the heating season the makeup amounts to about one-third of the boiler feed. The temperature is raised to about 200 deg. in the heater and to approximately 250 deg. in the economizer.

There is ample boiler capacity, as the plant has five 350-hp. units of the Aultman & Taylor water-tube type, each containing 2928 sq.ft. of heating surface and 54 sq.ft. of grate surface in a Hawley down-draft furnace. The working pressure allowed is 165 lb. gage, but in operation it averages about 155 lb. Illinois washed nut coal averaging about 12,000 B.t.u. per lb., and at times less, is burned. This is stored in a 380-ton bunker under the sidewalk and is conveyed in industrial railway cars to the boiler room, where it is dumped into the firing pit and is shoveled into the furnaces. The ashes are removed by a monorail-bucket system and raised into wagons by an ash hoist. Originally, the stack only extended through the roof of the eight-story section of the building, but was later carried to the top of the dome and is now 360 ft. high. It is square in section and, due to numerous turns and to the economizer, a draft of only 0.8 in. at the base is available. During the winter months three boilers have carried the load, and before the generating units were installed one boiler was sufficient during the summer.

Seven Otis passenger elevators of the inverted type and of 3000 lb. capacity serve the building. There are also four 4000-lb. freight elevators and four 2000-lb. hydraulic lifts to the second story. The equipment is served by one Laidlaw-Dunn-Gordon pumping engine, 16x20x20x5¼x24 in., and two duplex tandem-compound pumps, 16x25x7x3⅜x18 in., which work against a water pressure of 750 lb. maintained uniformly by an accumulator having a 10-in. ram weighted with 42 tons of cast iron.

For the pneumatic-tube mail-handling system there were installed four Ingersoll-Rand compressors driven by cross-compound engines ranging in capacity from 75 to 125 hp. A 20-ton Carbondale absorption plant cools the drinking water. The exhaust from the circulating and aqua ammonia pumps is sufficient for the absorption system so that it is only necessary to supply live steam to the pumps.

To this equipment the boiler plant supplies steam. Besides some miscellaneous machines, such as four Westinghouse air pumps, two small air pumps on the thermostatic temperature-regulating system, a vacuum cleaner, etc., take more or less live steam. An enormous quantity of hot water is required. This is heated in three 500-gal. tanks provided with coils supplied with exhaust steam.

The steam to the elevator pumps and the compressor engines of the pneumatic-tube system is measured by General Electric flow meters. The water to the boilers is also metered, and even the blowoff is measured, so that it has been possible to divide the steam consumption between the elevators, compressors and the heating system, the last-named, including the pumps and the miscellaneous apparatus in the plant, taking live steam. A flow meter has just been installed for the generating units, so that this department may also be credited with its proper steam consumption.

Exhaust from the various machines mentioned is supplied to the heating system, but before the engines were installed the supply was far short of the heat requirements. It was necessary to use a large quantity of live steam reduced to atmospheric pressure to conform with the pressure existing in the vacuum system.

The generating plant consists of two 200-kw. and two 100-kw. units made up of Harrisburg Foundry & Machine Works four-valve engines and Westinghouse three-wire, 125-250-volt generators. Each of the smaller engines has a cylinder measuring 14x15 in., and the cylinders of the larger engines are 17x20 in. The speeds are 250 and 200 r.p.m. respectively. As the meter for the engines was not installed during the month of March, no records of steam consumption in the plant are available, but the results obtained at the works for one of the smaller units are given in Table 1, and in Table 2 for a 200-kw. unit. To the smaller engine steam was supplied at 137.37 lb. gage, quality 97 per cent., and the exhaust was at atmospheric pressure. It will be noticed that the engine exceeded the guarantee in each case, and at its most economical load, three-quarter, developed an indicated horsepower-hour on 19.88 lb. of dry steam.

TABLE 1 RESULTS OF TEST ON 100-KW. UNIT

Load	¼	½	¾	Full	1¼
Guarantee, lb. per kw.-hr.	59.6	37.3	33.5	33.2	34.2
Actual, lb. per kw.-hr.	45.98	34.51	32.03	32.47	33.7
Dry steam per i.hp.-hr., lb.	25.1	21.02	19.88	20.35	21.03

TABLE 2. TEST RESULTS OF 200-KW. UNIT

Load	¼	½	¾	Full
Guarantee, lb. per kw.-hr.	58.3	37.1	33.3	32.8
Actual, lb. per kw.-hr.	41.6	31.67	30.43	32.04
Dry steam per i.hp.-hr., lb.	25.1	19.9	19.4	20.6

In Table 2 it is shown that the steam consumptions of the 200-kw. unit obtained by test are considerably below the guarantees. At three-quarter load the rate per indicated horsepower-hour is 19.4, and it will be noticed that the steam taken at one-half, three-quarter and full loads is very nearly the same. In this test the steam pressure averaged 141.5 lb. gage and the quality 99 per cent.

Table 3 gives the operating records of the plant from April, 1912, through March of the present year. Data for this period of time are given to show how the load varied for the different seasons of the year, and so that the corresponding months of the two years covered might be compared. From the records of coal consumption and kilowatt-hours per month it is evident that the load is gradually increasing, due to the greater bulk of mail handled by the post office. No cost figures, except the monthly sums paid the Edison Co., are given, but from the following data, the operating cost may be easily approximated.

During 1913 the price of coal per long ton averaged $3.10 and for the three months of 1914 it has averaged about $3.06, the grade being inferior to the coal used last year. Labor and supplies approximated $2000 per month. Water cost 52.5c. per 1000 cu.ft. and the electric rate for power and light was based on a sliding scale ranging from 1.7 to 1.9c. For anything over 100,000 kw.-hr. per month the rate was reduced to 0.9c. Dividing the price paid in 1912 by the total kilowatt-hours

TABLE 3. OPERATING DATA OF PLANT, COVERING A PERIOD OF TWO YEARS

								Steam Supply						Central Station Current					Coal	
Year	Month	Deg.-Hr. per Mo. below 70°	Deg.-hr. per Day below 70°	Av. Temp. Feed Water from Heater Deg. F.	Av. Temp. Feed Water from Econ. Deg. F.	Av. Steam Press. Lb. Gage	Av. Evap. per Lb. Coal	To Elevator Pumps, Lb.	To Pneumatic Tube Compressor or Engines, Lb.	To Pumps and Heating System Lb.	Blowdown Water, Lb.	Total Steam per Mo., Lb.	Av. Steam per Day Lb.	Power Kw.-Hr. per Mo.	Light Kw.-Hr. per Mo.	Total Kw.-Hr. per Mo.	Av. Kw.-Hr. per Day	Cost Current per Mo.	Coal per Mo. Long Tons	Av. Coal per Day, Long Tons
1912	April	15,000	500	160	247	156	7.7	1,599,284	1,799,236	3,634,770		7,033,297	234,443			104,090	3469	$1980.98	406	13.53
1912	May	9,196	296.6	166	248	157	7.1	1,501,227	1,385,113	2,132,994		5,019,334	161,914			102,850	3318	1987.07	316	10.20
1912	June	3,552	118	196	249	155	6.7	1,487,888	1,362,892	1,207,042		4,057,823	135,261			114,140	3804	2113.31	269.65	9.00
1912	July	1,000	32	200	250	153	7.8	1,391,374	1,430,154	3,061,293	116,203	5,999,024	193,517			117,160	3779	2088.19	278.3	8.98
1912	Aug.	1,752	56.5	204	251	157	9.6	1,473,237	1,275,730	2,823,987	128,116	5,701,070	183,905	50,470	69,760	120,230	3878	2056.60	259.11	8.36
1912	Sept.	4,176	139	191	250	156	9	1,459,351	1,300,076	2,669,118	124,950	5,553,495	185,116	49,020	68,070	117,090	3903	2129.33	275.46	9.18
1912	Oct.	10,050	324	159	245	157	8.2	1,497,175	1,466,499	3,334,573	129,115	6,427,362	207,334	47,680	78,020	125,700	4055	2172.21	352.	11.3
1912	Nov	19,616	653.8	151	237	157.4	7	1,584,140	1,254,515	4,564,113	124,950	7,527,718	250,924	43,060	74,150	117,210	3907	2216.56	474.8	15.83
1912	Dec.	27,586	889.8	117.7	236.1	157.3	6	1,614,141	1,491,888	5,194,755	129,114	8,429,898	271,932	39,910	83,130	123,040	3969	2298.43	619.07	19.97
1913	Jan.	40,240	1298	181	247.2	157.8	7.3	1,686,395	1,242,689	7,778,382	129,115	10,836,581	349,567	40,760	86,610	127,370	4109	2316.55	655.65	21.15
1913	Feb.	30,312	1082.5	187.8	249.1	156.9	7.4	1,799,082	1,010,185	7,631,197	116,620	10,557,084	377,039	25,550	76,110	101,660	3631	2055.63	630.6	22.5
1913	Mar.	26,090	841.6	187	248	156.9	7.1	1,808,995	1,278,115	6,282,729	129,115	9,498,954	306,418	26,130	84,210	110,340	3559	2067.60	587.75	18.96
1913	April	15,336	511	179.9	244.9	156.2	7	1,778,109	1,171,217	3,851,117	124,950	6,925,393	230,846	27,690	80,380	108,070	3602	1912.91	433.82	14.46
1913	May	9,336	301	196.3	245.7	156.5	7.4	2,021,948	1,506,844	2,354,873	129,115	6,012,780	193,961	35,340	79,220	114,560	3695	2007.26	352.8	11.4
1913	June	3,932	131	197	246.6	157	7.8	1,679,797	1,779,345	1,374,225	124,950	4,958,317	165,277	36,310	72,000	108,310	3610	1926.31	281.95	9.39
1913	July	576	18.5	192.6	242.7	157.6	7.1	1,732,052	1,872,207	1,453,242	103,292	5,160,793	166,477	39,090	70,790	109,880	3544	2036.87	315.95	10.19
1913	Aug	432	14	206.8	246.8	157.1	7.2	1,883,808	1,405,634	1,602,891	77,469	4,969,802	160,316	41,560	70,010	111,570	3599	1936.32	302.35	9.75
1913	Sept.	5,470	182.3	189.4	251	157	8	1,936,532	1,152,609	2,926,153	126,616	6,141,910	204,730	61,440	72,310	133,750	4458	2054.89	336.8	11.23
1913	Oct.	12,897	416	174.2	249.1	157.6	7.3	1,853,233	1,468,586	3,600,408	103,292	7,025,519	226,630	74,280	84,940	159,220	5136	2190.06	419.95	13.55
1913	Nov.	16,488	549.6	169.6	242.3	157	7.0	1,872,223	1,114,177	4,128,980	99,960	7,215,340	240,511	65,560	82,380	147,940	4931	2221.30	456	15.2
1913	Dec.	26,136	843.1	165.2	236.8	156.6	6.8	2,013,413	1,175,216	5,573,421	103,292	8,865,342	285,979	54,000	93,990	147,990	4774	2270.78	576.04	18.58
1914	Jan.	27,888	886.7	164.5	232.6	157.6	7.7	1,929,767	1,203,562	8,449,826	103,292	11,686,447	376,982	46,080	93,180	139,260	4492	2206.90	673.85	21.74
1914	Feb.	38,480	1495	177.2	243.9	157.8	7.3	1.800,900	798,549	9,418,885	93,296	12,111,630	432,558	36,970	81,810	118,780	4242	2026.55	733.72	26.2
1914	March	25,384	818.8	182.2	248.8	154.5	6.7	2,045,846	970,536	7,625,645	103,292	10,745,319	346,623	45,460	89,880	135,340	4366		713	23

supplied gave exactly 1.9c., and for the past year the rate figures nearly the same.

Without any records of steam taken by the generator units, perhaps the best way to arrive at a conclusion on the saving effected is to compare the total costs of operating the entire plant for the months of March in 1913 and in 1914, the latter month being the first for the generating plant. Reference to Table 3 will show that the degree-hours below 70 deg. are very nearly the same; March of 1913 is only 706 deg.-hr. colder. In March of 1914 more steam was used by the elevators, less by the compressor engines, more by the pumps, engine units and the heating system, so that, as shown in the totals, the excess for this year is considerably over 1,000,000 lb. The kilowatt-hours for the months are also greater by 25,000 and the coal consumption 125 tons more. By a readjustment of the existing force only two additional men were needed for the generating plant, adding $166 to the pay roll. The plant is run on three 8-hr. shifts.

For March of 1913 the operating expense, including current, coal, water, labor, supplies and repairs, totaled $5995.59. For March of 1914 the total was $4519.91. The difference is just $1475.68, notwithstanding the additional coal, steam, labor and the 25,000 kw.-hr. in excess of last year's figure. Charging this at 0.9c. per kw.-hr., the Edison bill for March of 1913 for an equal output would be increased $225, so that the total saving effected in the operating expenses would be $1700.

It might be remarked that the steam pipes to the engines were uncovered for the greater part of the month, and in order to tune up the different units, more of them were kept in service than was required by the load. As usual in starting up, the consumption of oil was excessive and the friction greater than ordinary. As time goes on, the engines should operate more efficiently. In the summer months the saving will be less; an estimate places it at $600 per month. On the other hand, the months colder than March should show a saving of more than $1700, and it must also be remembered that more steam has been furnished to the other departments.

Taking these things into account, a fair average for six months of the year should be about $1800 and $600 for the other months. The gross annual saving would then be $14,400. The extra labor, coal, supplies, etc., have already been included, so that the interest on the investment and depreciation are the only remaining factors to be deducted from the total saving in operating expense. For these items 10 per cent. is a fair charge on the $43,000 investment covering all of the new equipment. This amounts to $4300, and deducted from the gross, leaves a net saving of $10,100, equivalent to interest of 23.5 per cent. on the investment, which is not bad, and it would be difficult to obtain a higher rate except in plants operating under similar conditions.

C. M. Peterson is chief engineer of the plant.

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Two of the Most Recent Types of Oerlikon Steam Turbines are now running in the central electric station of Stockholm, these being of 10,000 hp. size. Turbine and dynamo make up a compact group, and the turbines are of a new design, which is claimed to have a number of advantages, one of these being a low steam consumption of 7.9 lb. per hp.-hour. The turbines operate at 3000 r.p.m. standard speed. Such turbines are made up as usual of blade wheels, each in a separate steam chamber, but the combination of speeds and pressures within the turbine is based on a somewhat novel theoretical design.

Synchronous Converters and Their Operation--II

By Eric A. Lof

SYNOPSIS—Various transformer connections for rotary converters, methods of starting and shutting down, and precautions to be observed. The characteristics and voltage ratios of rotary converters were discussed by the author in the April 21 issue.

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Transformer Connections: On account of the low alternating voltage which must be applied at the collector rings of a synchronous converter, it is usually necessary to provide transformers for stepping down the voltage of the supply circuit.

Both oil-cooled and air-blast transformers are used, and these in turn can be either of the single-phase or polyphase type. The single-phase type, however, is used almost exclusively, although in certain installations three-phase transformers may be found.

A separate transformer bank for each synchronous converter is preferable, as an entire unit can then be operated independently and a more flexible and reliable system obtained, also, the converters are less sensitive, the reactance of the transformers affording some flexibility between the converters, regarding field excitation, etc. If several converters were operated from the same transformer bank, the failure of any transformer would cripple the whole system. Moreover, the single transformer bank would have to be large enough for all the converters under maximum service conditions, while ordinarily it would be operating only at a fractional load and a correspondingly low power factor.

The voltage ratio of the transformers should be such as to give full-load secondary voltage corresponding to the full-load converter voltage. Primary taps should be provided for changing the ratio of transformation so as to keep the secondary voltage the same, should the voltage of the supply circuit change, due to additional load.

Starting taps are brought out from the secondary windings of the transformers and these taps are generally located at the middle points of the windings, for supplying three-phase converters, so as to give the machine one-half rated voltage for starting. For converters of 500 kw. and above, which are mostly of the six-phase type, two taps are provided in the transformer secondaries, located at respectively one-third and two-third points. Thus when connected to the first tap at starting, the converter will receive one-third normal voltage and when connected to the second it will receive two-thirds.

The diagrams shown in Figs. 7 to 12 represent various methods of connecting transformers and converters. The large circle in each diagram is assumed to represent the armature winding of a converter, the collector rings being omitted for simplicity. Fig. 7 shows the connections for a quarter-phase converter, the two terminals of each transformer secondary being connected to the converter winding at points 180 deg. apart. If the machine is to be used for supplying current to an Edison three-wire system, the neutral can be connected to the middle taps indicated in the secondary windings.

Fig. 8 represents a three-phase, delta-connected system with the transformer terminals connected to the converter winding at points 120 deg. apart. No neutral point can be obtained with this connection.

Fig. 9 represents a three-phase, star-connected system. Three corresponding transformer terminals are joined together, forming a neutral point, while the other terminals are connected to the converter winding at points 120 deg. apart. For three-wire service the neutral may be brought out, but it is important that the secondary windings be arranged so as to give good mutual induction in order to avoid shifting of the neutral due to unbalanced current. Arrangements should also be made with this system for opening the neutral connections during starting to avoid a short-circuit. The neutral connection should not be used for a three-wire direct-current system if the unbalanced direct current is large.

Transformers for star-star connection should be insulated for double-line voltage to ground and three times normal leg voltage across the windings. When so insulated there is no objection to the use, with converters, of transformers connected in this manner, and it is unnecessary to specify that the neutral must be grounded. This does not, however, necessarily apply to transformers for high-voltage transmission. There may be other problems involved which would make it undesirable to use the transformers connected in this way.

A so called "zig-zag" system of connections, as shown in Fig. 10, has been devised to eliminate the flux distortion, due to large unbalanced direct currents of a three-wire system. The winding consists of two coils on each leg, cross-connected as shown. The flux due to one coil in each leg will neutralize that due to the other coil on the same leg, and the only flux in the core will be that due to the alternating magnetizing current.

Six-phase synchronous converters can be supplied by transformers connected, as in Figs. 11 and 12. The diametrical connection, Fig. 11, is used most frequently as it requires only one secondary coil on each transformer. The middle points can be connected together and a neutral obtained, the unbalanced three-wire direct current having no distorting effect. With diametrical secondaries, the primaries should preferably be connected delta except with regulating-pole converters, where they must be connected in star. In such a case, the windings must be insulated for double-line voltage to ground and three times normal leg voltage across the windings, the same as for star-star-connected transformers.

Method of Starting

There are two common ways of starting a synchronous converter, from the alternating-current side and from the direct-current side.

Alternating-Current Starting: This consists in applying alternating current direct to the armature windings at a reduced voltage obtained from partial voltage taps on the low-tension side to the step-down transformers. After the machine has reached synchronous speed and the right polarity has been obtained, normal voltage is applied. This method of starting is by far the best on account of its simplicity and reliability; no synchronizing is necessary and the time taken to put the machine in service is a minimum. Under normal conditions it takes about one minute to get the machine into service, but several instances are on record in which the time consumed was about 20 sec.

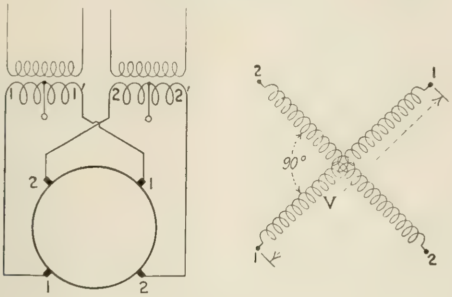

FIG 7

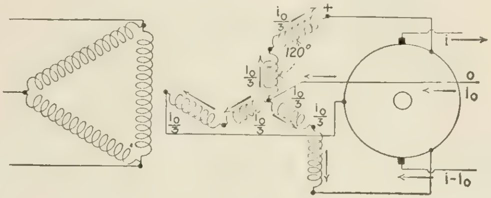

FIG 10

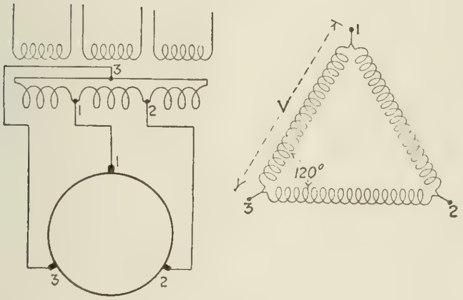

FIG 8

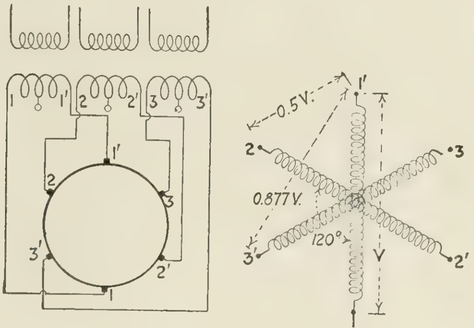

FIG 11

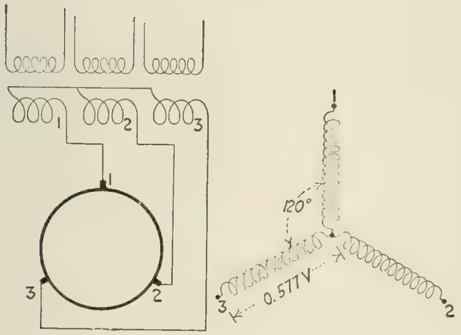

FIG. 9

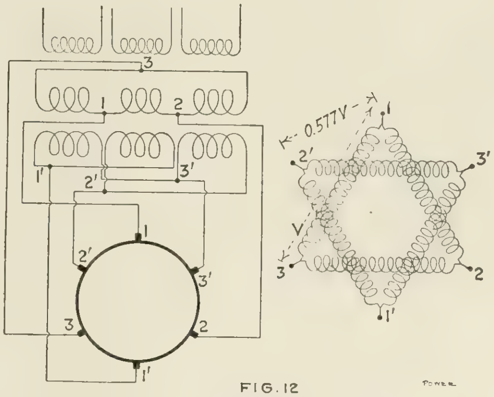

FIG. 12

DIFFERENT METHODS OF CONNECTING TRANSFORMERS AND ROTARY COVERTERS

Two-phase machines are usually started by means of one-third and two-thirds voltage taps on the transformers and require two double-pole, double-throw switches. Three-phase machines are started from one-half voltage taps and require one double-pole, double-throw switch. Six-phase, diametrically connected machines are started from one-third and two-thirds voltage taps and require two triple-pole, double-throw switches.

DIRECT-CURRENT STARTING: When direct current is available a machine can be started as a direct-current motor and synchronized on the alternating-current side. The only advantage of this method is the smaller amount of power required from the line to start. It has the disadvantage of taking considerable time, and there is danger of closing the circuit when the machine is out of phase, which might result in the shutting down of the entire system.

STARTING BY INDUCTION MOTOR: This method consists of starting by means of an induction motor mounted on an extension of the converter armature shaft. It possesses the disadvantages of direct-current starting, with the additional disadvantages that the starting motor often occupies valuable space, increases the cost of the machine, and there is a slight loss of efficiency on account of the constant windage loss of the starting motor.

COMBINATION ALTERNATING- AND DIRECT-CURRENT STARTING: When direct current is available a combination of direct- and alternating-current starting can sometimes be used to advantage. The machine is started from rest by direct current, and after the direct current has been shut off it is thrown on the lowest voltage taps used for alternating-current starting. This method is used by two or three large companies with success.

SWITCHING

The switching equipments furnished with synchronous converters vary considerably, but the following instructions apply generally to standard compound-wound converters used in railway service. The diagrams, Figs. 13 and 14, represent, respectively, the switching arrangements for three-phase and six-phase converters. Referring to these and, assuming that all the switches are open before starting and that the plug is inserted in the potential receptacle on the direct-current switchboard panel, thus connecting the machine to the voltmeter:

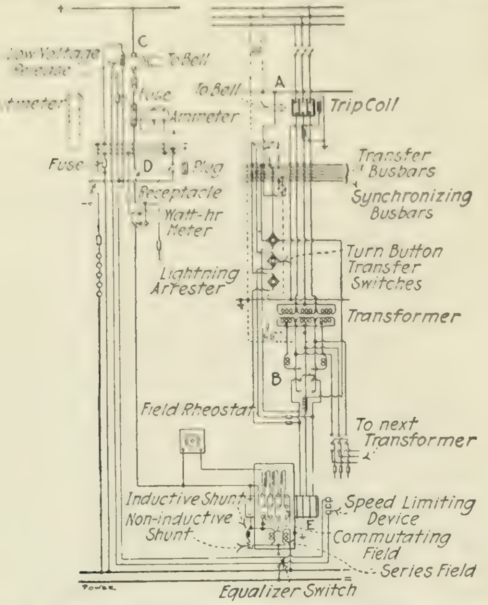

FIG. 13. CONNECTIONS FOR THREE-PHASE CONVERTER

First: Close the main high-tension switch *A*.

Second: Close the starting switch *B* upward.

(For six-phase machines with tandem switches both switches *B* and *B′* should be closed upward, Fig. 14.)

The machine will then run up to speed and lock in step, which will be indicated by a cessation of the beats of the direct-current voltmeter.

Third: Close the equalizer switch *G*.

Fourth: Close the field break-up and reversing switch *E* into the top position.

Fifth: For three-phase machines throw the starting switch *B* quickly from the top to the bottom contacts, Fig. 13.

With six-phase machines, Fig. 14, throw the starting switch *B′* quickly from the top to the bottom contacts and then switch *B* to the bottom contacts. Finally open switch *B′*.

Sixth: Adjust the direct-current voltage to approximately that of the busbars.

Seventh: Push up the low-voltage release of the circuit-breaker and close the circuit-breaker *C*.

Eighth: Close the main switch *D*.

Ninth: Adjust the division of load between the machines if more than one are in service by means of the field rheostats.

If other machines are on the line when a compound-wound converter is started, the correct polarity may be insured by closing the equalizer switch *G* when the machine locks in step. By watching the swing of the direct-current voltmeter as the machine approaches synchronism, switch *G* may be closed just previous to the last two or three swings, thus insuring proper locking on the first trial, if there is current for the series field from other machines. If the machine should lock with the wrong polarity, as indicated by the direct-current voltmeter needle going down off the scale, the field switch *E* must be closed first into the down position, which will cause the voltmeter to return above zero, after which the switch *E* must be pulled out and closed into the top position. The reversal of polarity should be made while the machine is running on the first starting tap.

SHUTTING DOWN

To shut down a synchronous converter, open the circuit-breaker *C*, pull out and turn the circuit-closing auxiliary switch to stop the ringing of the alarm bell; open the main switch *D;* open the high-tension alternating-current oil switch *A;* allow the machine to run down in speed until the voltage falls off to about 100 before opening the field switch *E* or the starting switch *B;* then open the field switch *E*, equalizer switch *G* and starting switch *B*.

PRECAUTIONS

The following precautions should be kept in mind when starting or shutting down synchronous converters:

Don't open the field switch *E* until the machine voltage has run down; otherwise the arc on opening the inductive field circuit may be blown by the armature blast from point to point, causing a short-circuit, or the strain may injure the insulation of the field winding.

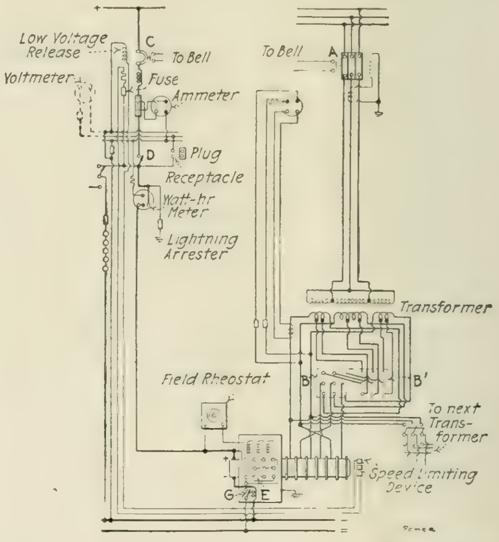

FIG. 14. CONNECTIONS FOR SIX-PHASE CONVERTER

Don't open the starting switches until the machine voltage has run down to zero. This leaves the transformers without a heavy residual magnetism, which tends to cause an extra rush of current when they are subsequently thrown into circuit.

Don't open the oil switch with the converter on the starting tap and the field closed; otherwise the converter may build up to full voltage, tending to run up the transformers to considerably above normal voltage.

Don't parallel the machines on the direct-current side without closing the equalizer switches.

Don't start the converters with the field switch E closed either in up or down position, or with the series-shunt switch closed.

Don't close the alternating-current starting switch slowly into the top contacts, as the rush of current may pit the tips of the clips and thus prevent the blades from going in.

Don't close any switch slowly.

Don't close the circuit-breaker with the main switch D closed.

Don't close the circuit-breaker after a heavy short, without plugging in the voltmeter to make sure that the polarity is not reversed.

The diagram in Fig. 15 represents the field connections of a regulating-pole converter. In the main field circuit is the usual four-pole, double-throw, field break-up and reversing switch and rheostat. The regulating field windings on the smaller poles, and compensating field windings on the larger or main poles, are connected in multiple across the double-dial rheostat. This rheostat when turned from one extreme to the other will gradually change the excitations of the fields from a maximum in one direction to zero and then a maximum in the other direction. The compensating field winding also has a rheostat in series so that the proper relative strength between the regulating and compensating fields is adjustable to give the closest approximation to unity power factor at an average load throughout the voltage range obtainable by changing the excitation of the regulating field with the double-dial rheostat. (When the compensating field winding is not provided the power factor is kept at unity by the main field rheostat.) The compensating field rheostat can be best adjusted after the machine is installed for permanent operation.

In starting from the alternating-current side the field circuits are opened by the break-up switches. When synchronism has been reached on the first starting tap, proper polarity is obtained with the main field reversing switch, as previously described for the other converters. When the machine has been thrown to the full voltage of the transformer, the regulating and compensating field break-up switches are closed and the direct-current voltage is adjusted with the double-dial rheostat to the proper value for connecting to the direct-current busbars.

When starting from the direct-current side, the main field is excited to full strength the same as for the usual type of synchronous converters, and when running at approximate synchronism, the compensating and regulating field circuits are closed and adjusted to give the same voltage across the collector rings as that across the transformers. The speed is then adjusted to synchronism and proper phase relation by the main field rheostat before closing the main switches connecting to the transformer.

The regulating and compensating field windings on any pole are connected to excite in opposite directions so the resultant combined excitation of the whole pole, when the voltage is changed by the regulating field, will remain the same and will thus not affect the power factor appreciably. The compensating field when properly adjusted with the rheostat in its circuit will also make it easier to hold the speed constant when adjusting the alternating voltage for synchronizing when starting from the direct-current end.

COMMUTATING-POLE CONVERTERS

The usual procedure, as described, for standard converters applies to those of the commutating-pole type, but in addition the brushes should be raised before starting and lowered after the machine is synchronized at full voltage—that is, the brushes should be lowered after the fifth operation.

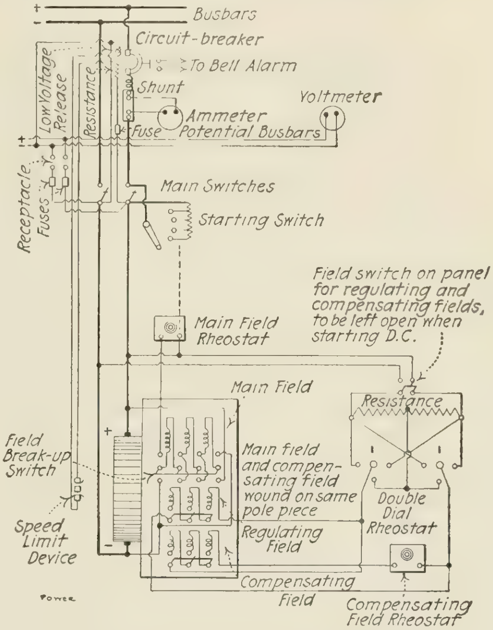

FIG. 15. CONNECTIONS ON DIRECT-CURRENT SIDE OF REGULATING-POLE CONVERTER

OPERATION

It is important that two or more converters operated in parallel should divide their loads in proportion to their ratings. The division will be governed by the direct-current voltages, and these can be regulated by changing the applied alternating voltage, by one of the methods previously described. It is evidently necessary that all of the machines operating in parallel should have the same voltage regulation from no load to full load, and if a battery is also operated in parallel the voltage drop should be sufficiently large to cause the battery to take the excessive loads. If no battery is used, it will be more economical to have the machines designed for a smaller voltage drop.

Synchronous converters should always be operated at the voltage for which they are designed. However, it appears to be a common weakness among operators to run converters 5 to 10 per cent. above normal voltage on the direct-current side. This is done, of course, by increasing the shunt-field excitation to such an extent that the shunt field alone draws a leading current at no load, over and above which the series field adds additional leading current as the loads come on. The result of such operation is to practically double the average heating in the armature conductors at full load above that of unity power factor, on which the converter guarantees are based. More than this, such an operation increases the heating of certain bars near the collector-ring taps to three or four times the normal value, in addition to the heat resulting from increased core loss in the armature due to overvoltage. The result is to practically cut down the capacity of the converter some 30 to 50 per cent.

In most cases, the average load is so low that no trouble is had, but as systems grow and load factors improve, the difficulty is likely to appear. The proper cure for this evil is to utilize proper taps in the transformers, so as to impress an alternating voltage sufficiently high, and to compel the operators to adjust the direct-current voltage for a sufficiently low value as to cause the converter to draw a considerable lagging current at no load, as previously explained.

⁂

Economical Selection of Belts and Pulleys

By W. F. Schaphorst

SYNOPSIS—Data pertaining to the selection of pulleys and belts which will give the best results with the least initial cost. Tables and curves are employed to assist the reader in making a determination of pulley and belt sizes.

⁂

In a prominent factory in the city of New York there is an engine that runs 75 r.p.m., transmitting 100 hp. from a 5-ft. pulley to a 4-ft. pulley. The distance between centers is 25 ft. Because of the slow engine speed and the relatively small driving pulley the belt has caused considerable trouble by slipping. Its velocity is less than 1200 ft. per min., but a velocity of 3000 ft. per min. would not be too high.

A 10-ft. driving pulley and an 8-ft. driven pulley would give the same final speed, and there would be less tendency of the belt slipping, because of the greater belt contact. The cost of the larger pulleys plus the cost of the correspondingly smaller belt required would be about $270 less.

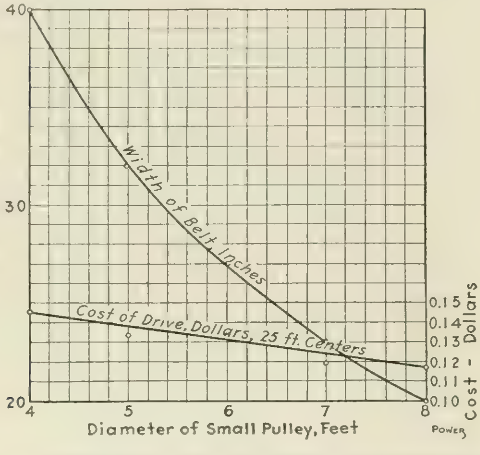

FIG. 1. DEVELOPING 100 HP., SPEED OF DRIVING PULLEY 75 R.P.M.

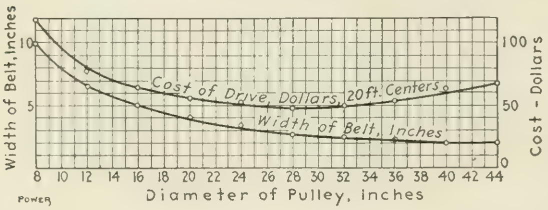

FIG. 2. TEN HP., SPEED OF DRIVING AND DRIVEN PULLEYS 400 R.P.M.

Large pulleys should always be used, wherever possible, and especially if they can be proved most economical by the method cited.

In the factory mentioned a 40-in. belt is used. By doubling the diameters of the pulleys the belt speed is doubled and its transmission capacity is increased twofold. A belt only one-half as wide, or 20 in., would, therefore, suffice and its cost would be but one-half as great. The cost of the pulleys would be greater than in the present plant, but that increased cost would be more than counterbalanced by the decreased cost of the belt; $270 could be saved, and the transmission defects would be eliminated.

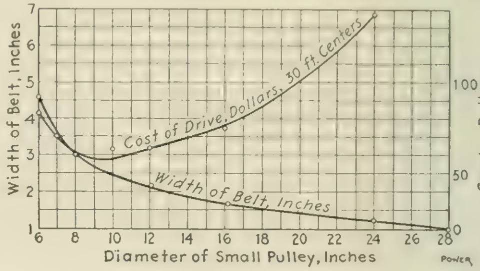

FIG. 3. TEN HP., LARGE PULLEY 300 R.P.M., SMALL PULLEY 1200 R.P.M.

TABLE I.

Diam. Small Pulley, In.	Diam. Large Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Small Pulley	Cost of Large Pulley	Total Cost
48	60	40	64	$1023	$179	$253	$1455
60	76	32	67.7	867	187	288	1342
72	90	27	71.2	769	239	346	1354
84	106	23	74.7	687	211	299	1197
96	120	20	78.25	627	234	324	1185

In belt computations the rules that are most widely used are as follows:

Rule 1. A single-ply belt 1 in. wide, running 800 ft. per min. will transmit 1 hp.

Rule 2. A double-ply belt 1 in. wide, running 500 ft. per min. will transmit 1 hp.

To convert rule No. 1 into a formula applicable to most ordinary conditions, let

W_1 = Width of single-ply belt in inches;
W_2 = Width of double-thickness belt in inches;
H = Horsepower to be transmitted;
D = Diameter of driving pulley in feet;

N = Revolutions per minute of driving pulley;

πDN = Speed of belt in feet per minute;

$\frac{\pi DN}{800}$ = Horsepower a single thickness belt 1 in. wide will transmit.

Therefore,

$$W_1 = H \div \frac{\pi DN}{800} = \frac{800\,H}{\pi DN} = \frac{254\,H}{DN} \qquad \text{(I)}$$

By the same process rule No. 2 becomes

$$W_2 = \frac{159\,H}{DN} \qquad \text{(II)}$$

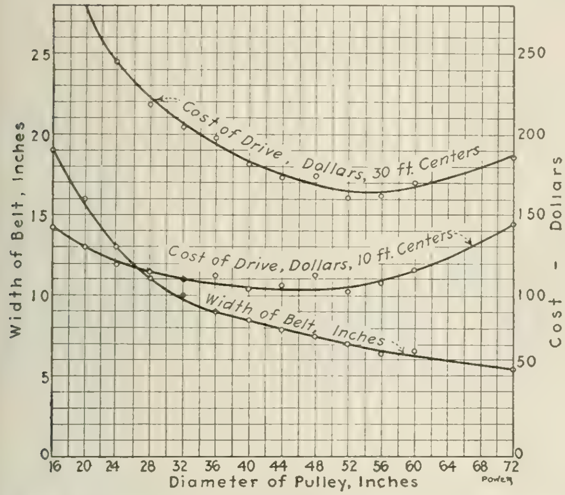

Fig. 4. Twenty Hp., Speed of Driving and Driven Pulleys 200 R.p.m.

Adhering to the speed conditions laid down by the factory mentioned, a small pulley 5 ft. in diameter and a 6.25-ft. driving pulley would effect practically the same final speed. Applying formula (II) it is found that a 32-in. belt would be needed. Next, 6-ft. and 7.5-ft. pulleys with a 27-in. belt could be used.

TABLE II.

Diam. Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Pulleys	Total Cost
8	10	42	$109	$10	$119
12	6½	43	67	12	79
16	5	44⅙	53	12	65
20	4	45⅙	43	13	56
24	3¼	46¼	36	15	51
28	2¾	47⅓	31	18	49
32	2½	48⅓	29	21	50
36	2¼	49½	27	24	51
40	2	50½	24	37	61
44	2	51½	25	42	67

TABLE III.

Diam. Small Pulley, In.	Diam. Large Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Small Pulley	Cost of Large Pulley	Total Cost
6	24	4½	64	69	3	9	81
7	28	3¾	64½	58	3	9	70
8	32	3	65½	47	3	11	61
10	40	2¾	66½	44	3	18	65
12	48	2¼	67⅚	37	4	24	65
16	64	1¾	70½	30	5	39	74
20	80	1½	73	26	6	..	..
24	96	1¼	75	23	8	109	140
28	112	1	78⅓	19	9	....	..

It is most convenient to tabulate these figures as in Table I with the length of the belt, the cost of the belt, and the costs of the pulleys. The total costs are then readily determined and compared. Plotting the total costs and belt widths, as in Fig. 1, the decreases in both are plainly shown.

The costs of pulleys and belting used in all of these tables are taken from the catalog of a manufacturer of transmission machinery and may be considered reliable for the problems solved here. Although, in this factory problem, the constant decrease in cost with increase in pulley diameters indicates that even larger pulleys might be still more economical, the curve could not be continued in this case because the limiting diameter of standard iron pulleys made by the manufacturers is 10 ft. Special pulleys would undoubtedly cost too much to be considered.

Table II and curves in Fig. 2 show that where 10 hp. is to be transmitted from a shaft making 400 r.p.m. to a second shaft 20 ft. away making 400 r.p.m. also, 28-in. pulleys and a 2¾-in. single belt would be most economical. The cost curve in this case being almost flat from the 20-in. pulley size to the 36-in. pulley size and the designer is allowed a wide range of choice, but it should be remembered that large pulleys generally give least trouble from slipping. The belt speed of 3000 ft. per min. with 28-in. pulleys is not excessive and may be allowed without question. Formula I was used in computing the belt widths in this and the other curves and tables.

TABLE IV.

Diam. Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Pulleys	Total Cost
16	19	64⅙	$293	$31	$324
20	16	65⅙	250	33	283
24	13	66¼	206	37	243
28	11	67¼	177	41	218
32	10	68⅓	164	41	205
36	9	69⅓	150	48	198
40	8	70⅓	135	46	181
44	7	71½	120	53	173
48	6½	72½	113	60	173
52	6	73½	106	54	160
56	5½	74½	99	62	161
60	5½	75⅔	100	70	170
72	4½	78⅙	85	100	185

Fig. 3 shows the least expensive combination where 10 hp. is to be delivered from a pulley making 300 r.p.m. to a smaller pulley making 1200 r.p.m. Distance center to center, is 30 ft. A small pulley 9 in. in diameter, a 36-in. driving pulley, and a 2¾-in. belt will do very well. Table III gives the computed results from which these curves were plotted.

Fig. 4 shows that the best sizes are not always dependent upon the distance between shaft centers. The upper cost curve shows that where driving and driven pulleys are the same size, where the speed is 200 r.p.m., where 20 hp. is to be transmitted and where the distance between centers is 30 ft., 52-in. pulleys and a 6-in. belt would be most economical. The lower cost curve is based upon the same conditions with the exception that the distance between centers is shortened to 10 ft. Although this shortens the belt considerably the plotted point on the curve nevertheless indicates that 52-in. pulleys and a 6-in. belt are again most desirable as regards first cost. The upper curve is plotted from Table IV and the lower curve is plotted from Table V.

TABLE V.

Diam. Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Pulleys	Total Cost
16	19	24⅙	110	31	141
20	16	25⅙	97	33	130
24	13	26¼	82	37	119
28	11	27¼	72	41	113
32	10	28⅓	68	41	109
36	9	29⅓	63	48	111
40	8	30⅓	58	46	104
44	7	31½	53	53	106
48	6½	32½	51	60	111
52	6	33½	48	54	102
56	5½	34½	46	62	108
60	5½	35⅔	47	70	117
72	4½	38⅙	42	100	142

It is, therefore, evident that the determination of pulley sizes need not be guesswork. After plotting curves similar to these the designer can exercise his judgment (which is needed in almost every design problem) to the best advantage. This method is simple, requires little time, and is sure.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Hunter shows me something about pipe lines as found at the average colliery, the method of supporting them and the value of suitable pipe covering. Ways of extending a pipe line above a railroad track are illustrated and described.

A study of pipe lines extending from the boiler houses to the hoisting engines, pumps, breakers and fan engines interested me. On several occasions Hunter and I went to various collieries just to note the method of pipe-line extensions and the condition in which they were kept.

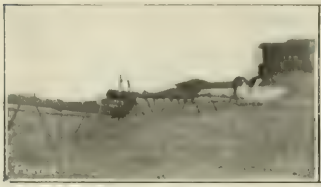

Fig. 1. Pipe Line in Service Twenty Years

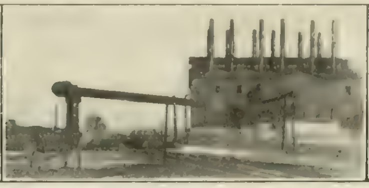

Fig. 2. Pipe Line and Expansion Joint

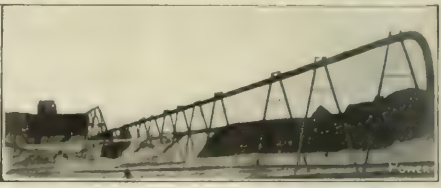

Fig. 3. S-Bends for Taking Care of Expansion and Contraction

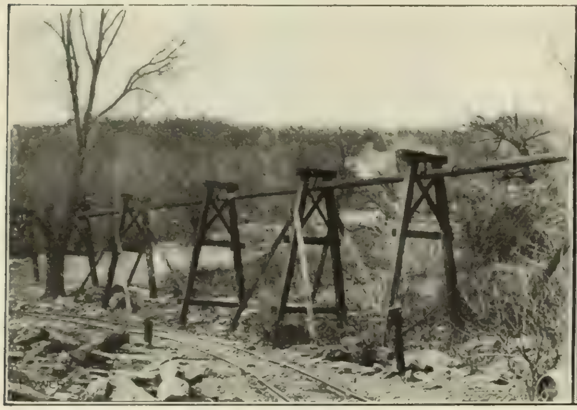

Fig. 4. A-Frame Pipe-Line Supports

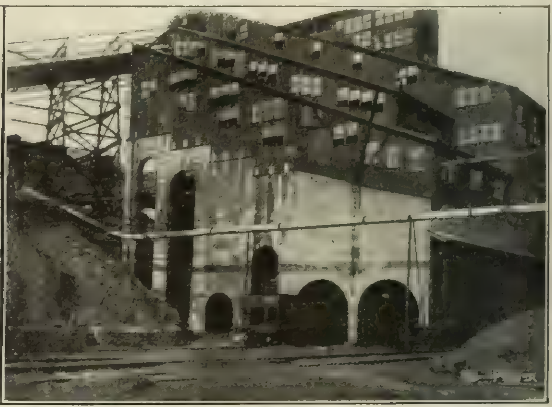

Fig. 5. Another Method of Supporting a Pipe Line

One pipe line, Fig. 1, was of exceptional interest, it having been in service something like 25 years, I think the superintendent told us. Although it shows irregularities, due to the settling of the surface when the old mine workings caved in, the joints are free from leaks. At the time the settling occurred only a few of the joints required attention. A first-class job must have been made when the pipe line was first installed.

A common expansion joint is shown in the foreground, consisting merely of four elbows and three nipples, making, when screwed together, an offset joint. This construction gives the pipe line on both sides of the joint an opportunity for free expansion as the temperature of the steam line changes. Hunter volunteered the information that we would find many such arrangements, and we did.

In Fig. 2 is a similar expansion joint, with the exception that a long nipple is used in the near vertical pipe. The longitudinal expansion is taken up at both top and bottom nipple joints, and the movement of both is but half what would take place in a single joint if the upper pipe dropped to a double ell and nipple. As these lines frequently run 8 and 10 in. in diameter in long lengths and carry a steam pressure around 150 lb., the expansion between a cold and a hot state is considerable. The pipe line illustrated is the main steam supply from the boiler house to the points of utilization.

Various methods are employed to suspend these lines. A common practice is to use metal or wooden A-frames having a tie piece at the top through which a U-bent piece, holding the pipe, is placed, the pipe being adjusted and held in position by nuts on the two ends of the yoke piece. This is illustrated in Figs. 1 and 3.

"There seems to be a difference of opinion regarding the proper height at which pipe lines should be suspended from the ground," said Hunter. "Some maintain that when the pipe lines are carried low (as shown in Fig.

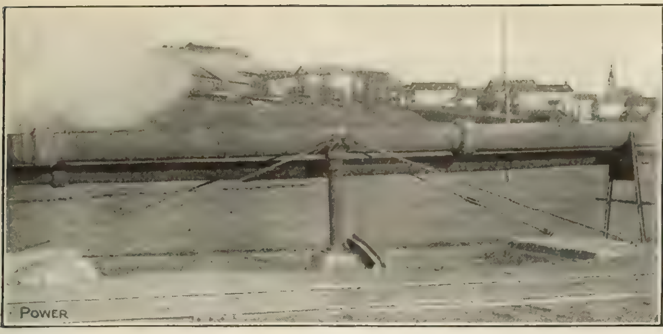

Fig. 6. A Neat Job of Pipe Covering and Anchor Stanchion

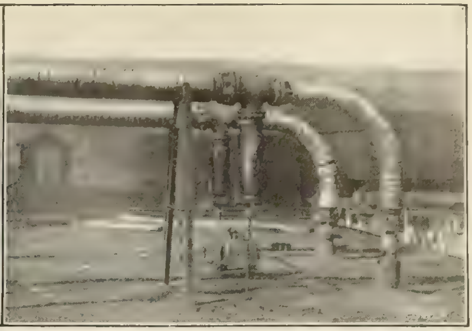

Fig. 7. Separator on Pipe Line Leading to Mine

1) that they are subjected to less condensation losses than when put up high, (indicated by Fig. 3), as the latter is more exposed to cold air currents. One advantage of the latter construction, however, is ample room for teams, etc., to pass under the pipe between the supports."

Another means of suspending pipe lines was noted, as illustrated in Fig. 4. This consists of a wooden A-frame with an eye-bolt passing through the top cross piece and held in place by a nut. A two-piece clamp is fitted around the pipe and bolted at the top and bottom, the upper bolt passing through the eye-bolt.

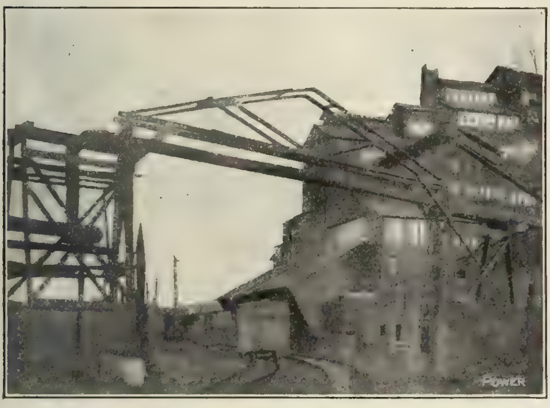

Fig. 8. Pipe-Line Support over Tracks

Still another way, shown in Fig. 5, consists of a metal upright piece having a forked upper end in which the steam pipe rests. Each supporting column may be secured by one or two diagonal braces from the top to an anchor buried in the ground. With but few exceptions, the steam pipes are covered with some kind of pipe insulation. In many instances, it was in a dilapidated condition, which must have allowed a large amount of condensation.

"The importance of proper covering for steam pipes and all apparatus about a steam plant where used cannot be too much emphasized," said Hunter. "Even with the best insulation, there will be some loss by condensation. The loss of heat from a bare steam pipe is taken by some authorities as approximately 3 B.t.u. per square foot per hour per degree of difference in temperature. For instance, taking a 10-in. pipe, 200 ft. long, carrying a steam pressure of 150 lb., 24 hr. per day, the approximate loss per year would be 3,528,000,000 B.t.u., or about 122 tons of coal. Just how much this loss will be reduced depends upon the value of the pipe covering."

A good example of pipe covering is shown in Fig. 6. On many lines we found that the flanges are left uncovered, probably to facilitate repacking the joint, but this omission permits of unnecessary condensation.

The illustration also shows a method of anchoring a pipe line. The anchor is a round metal upright stand, fitted at the bottom with a flange coupling, secured to a concrete base. A collar is fitted to the top of the stand and clamps the pipe. On each side of the clamp is a projection to which turnbuckles and rods are secured as shown. These rods are anchored in concrete and when the turnbuckles are tightened the upright stand is braced from both sides.

Some kind of a separator is generally used on long pipe lines. In Fig. 7 is shown the pipe for supplying underground apparatus, which runs from the boiler house and drops to the workings below through bore holes. Between the horizontal pipe and the bent section of each line, a separator is placed to remove the water of condensation before it reaches the vertical pipes. The separators on the two pipes shown are connected to a trap which takes care of the water. The pipes are insulated and wound with cloth.

It frequently happens that a pipe line must pass over a railroad track; passing the pipe under the rails forms a pocket in which water would collect. This can be overcome by building a framework above the tracks to support the line, as in Fig. 8. A more easily constructed pipe support can be made by placing an old rail on each side of the track, in a cement foundation, and fitting a

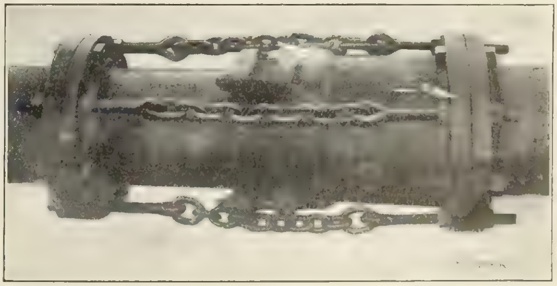

Fig. 9. Expansion Joint on Air Line

grooved pulley at the upper end of each rail. A wire rope or a chain is secured to an anchor outside of the rails and is passed over the two pulleys. A saddle is placed midway between the rails which support the pipe line at this point and is attached to the rope or chain, one of which should be made with a turnbuckle. As the turnbuckle is tightened, the tendency is to lift the pipe saddle. A threaded through rod from one rail to the other, with a nut on both sides of each rail, prevents the rails from bending in at the top. If the line is too heavy for two rails to support, a duplicate rail on each side of the track can be used with the grooved pulley attached to a cross piece. This arrangement would doubtless support any weight pipe line used about a mine.

In one instance, a long air pipe line was provided with an expansion joint which gave trouble by pulling out when the pipe contracted. To prevent this, four chains of suitable length were linked to two eye-bolts, the ends of which were put through the flange bolt holes, as in Fig. 9. A nut on each side of the flanges served the purpose of the regular flange bolts, and the chain prevented the joint from pulling out.

There were doubtless many other arrangements of pipe lines which we did not see, but even so, darkness found us plodding around culm piles and past somber mine shafts as we made our way back to the hotel and supper.

⁂

Working Up a Boiler Test--II

By F. R. Low

SYNOPSIS—An efficiency test is worked up item by item. The reduction to a dry coal and combustible basis is explained. How to find the evaporation per pound of coal as fired, per pound of dry coal, or of combustible under actual conditions or from and at 212. Different boiler efficiencies, boiler horsepower, and the cost per 1000 lb. of steam.

⁂

Suppose a boiler has been tested for efficiency; to see how well it is doing rather than how much it will do. This involves the determination of the amount of fuel used as well as the amount of water evaporated, and, if anything more than an approximation is wanted, the quality of both the fuel and the steam.

The accompanying table is the short form of test report recommended by the Committee on Boiler Tests of the American Society of Mechanical Engineers. Let us take it item by item and work out the values which are computed or deduced from those which are given.

Items 1 to 13 are the observed quantities and require no explanation.

Item 14 is the weight of coal fired, including moisture and the equivalent in coal of anything else that was put into the furnace, but not including unburned coal taken out of the furnace when cleaning or at the end of the test. One pound of wood may be taken to be equal to 0.4 lb. of coal.

Item 15 is obtained by weighing a sample of the coal before and after drying.

Item 16 is the weight of coal as fired less the moisture which it carried.

Then $1 - 0.0382 = 0.9618$

of it was dry coal, and

$$\overset{\text{item 14}}{\text{[illegible]}} \times \overset{\text{item 15}}{0.9618} = \overset{\text{item 16}}{13{,}199.7432}\ \textit{lb.}$$

Item 17 is the weight of stuff which went from the furnace into the ashpit during the test. It will be the ash and unburnable part of the coal plus whatever unburned coal gets through with it. It should, of course, be weighed dry.

Item 18 is the ratio of the ashpit refuse to the dry coal, the weight of stuff taken from the ashpit divided by the weight of coal (corrected for moisture) weighed to the furnace during the same time. It is expressed in per cent. and should not be confused with the percentage of ash in the coal by analysis, as it may contain a considerable proportion of unburned coal itself. In our case the weight of dry coal fired was 13,199.74 and that of the ashpit refuse 1238 lb. The ash and refuse are, therefore,

$$\frac{\textit{item}\ 17 \times 100}{\textit{item}\ 16} = \frac{1238 \times 100}{13{,}199.74} = 9.38\ \textit{per cent.}$$

Item 19, the weight of water fed to the boiler during the test must be corrected for any difference in level at the beginning and end of the test and, if there is a very great difference in the pressure, for that also. It should truly represent the weight of water which has been put into the boiler and disappeared during the test; the amount weighed in plus or minus the amount required to make the water contents of the same weight that they were at the commencement. It should also be corrected as explained in the last article (page 371, POWER, Mar. 17) for any leakage or blowing down, which has occurred, while the test was in progress. In our case the weight is given as 111,654 lb.

Item 20. The steam made by the boiler may be moist or superheated. This item is the equivalent, in dry-saturated steam of the average pressure, of the steam as actually made. In our case the steam is moist; only 97.3 per cent. or 0.973 of the water has been actually evaporated, the rest being carried along by the steam as entrained moisture. The water actually evaporated (item 20) is, therefore,

$$\frac{\textit{item}\ 19 \times \textit{item}\ 13}{100} = \frac{111{,}654 \times 97.3}{100} = 108{,}639.34$$

If the steam were superheated the equivalent amount of dry-saturated steam of the same pressure could be found by dividing the difference between the total heat per pound (the **h** of the Marks-Davis superheated steam tables) and the heat of the liquid (the *h* of the tables) by the difference between the total heat of dry-saturated steam of the given pressure (the *H* of the tables) and *h*; and multiplying the pounds of water weighed in (item 19) by the quotient. The total heat **h** of steam of 127 lb. gage pressure, say, 142 absolute, superheated 100 deg. is 1248.1 B.t.u., that of dry-saturated steam of the same pressure 1192.5. The heat of the liquid at the given feed-water temperature 196 deg. (item 10) is, from the steam table, 163.92 B.t.u. To make a pound of steam under these conditions would take

Results of Boiler Test A. S. M. E. Short Form Code of 1912

1	Test of.......... boiler, located at.................... to determine	conducted by....................	
2	Kind of furnace		
3	Grate surface		62.50 sq.ft.
4	Water-heating surface		3,500 sq.ft.
5	Superheating surface		
6	Date		
7	Duration		12.50 hr.
8	Kind and size of coal		

AVERAGE PRESSURES, TEMPERATURES, ETC.

9	Steam pressure by gage		127 lb.
10	Temperature of feed water entering boiler		196 deg. F.
11	Temperature of gases leaving boiler		
12	Force of draft between damper and boiler		
13	Quality of steam		97.3%

TOTAL QUANTITIES

14	Weight of coal as fired		13,724 lb.
15	Moisture in coal		3.82%
16	Weight of dry coal consumed	Item 14 × (1—item 15)	13,199.74 lb.
17	Weight of ash and refuse		1,238 lb.
18	Ash and refuse in dry coal	Item 17 ÷ item 16	9.38%
19	Weight of water fed to boiler		111,654 lb.
20	Weight of water evaporated	Item 19 × item 13 if moist Item 19 × $\frac{h - h}{H - h}$ if superheated	108,639.34 lb.
21	Equivalent evaporation from and at 212°	Item 20 × $\frac{H - h}{970.4}$	115,846.84 lb.

HOURLY QUANTITIES AND RATES

22	Dry coal consumed	Item 16 ÷ item 7	1,055.98 lb.
23	Dry coal per sq.ft. of grate	Item 22 ÷ item 3	16.9 lb.
24	Weight of water evaporated	Item 20 ÷ item 7	8,691.15 lb.
25	Equivalent evaporation from and at 212°	Item 21 ÷ item 7	9,267.75 lb.
26	Equivalent evaporation from and at 212° per sq.ft. of water-heating surface	Item 25 ÷ item 4	2.65 lb.

CAPACITY

27	Evaporation per hr. from and at 212°	= item 25	9,267.75
28	Boiler horsepower developed	Item 27 ÷ 34.5	268.63 hp.
29	Rated capacity	Item 30 × 34.5	12,075 lb. per hr.
30	Rated capacity	Item 29 ÷ 34.5	350 hp.
31	Ratio of developed to rated capacity	Item 27 ÷ item 29, or item 28 ÷ item 30	76.75%

ECONOMICAL RESULTS

32	Water fed per lb. of coal fired	Item 19 ÷ item 14	8.14
33	Water evaporated per lb. of dry coal	Item 20 ÷ item 22	10.29
34	Equivalent evaporation from and at 212° per lb. of dry coal	Item 21 ÷ item 16	8.78
35	Equivalent evaporation from and at 212° per lb. of combustible	Item 21 ÷ Item 16 — item 17	9.68

EFFICIENCY

36	Calorific value of 1 lb. of dry coal		12,700 B.t.u.
37	Calorific value of 1 lb. of combustible	Item 36 ÷ % ash in coal	13,700
38	Efficiency of boiler furnace and grate	(Item 35 × 970.4 × 100) ÷ Item 37	68.57%
39	Efficiency of boiler and furnace	(Item 34 × 970.4 × 100) ÷ Item 36	67.09%

COST OF EVAPORATION

40	Cost of coal per ton delivered in boiler room		3.60 dollars
41	Cost of coal required to evaporate 1000 lb. of water from and at 212°	$\frac{1000 \times \text{Item 14} \times \text{Item 40} \times 100}{\text{Item 21} \times \text{No. of lb. in ton}}$	21.33 cents

(*superheated* **h** − *h*) 1248.1 − 163.92 = 1084.18 B.t.u.
(*dry saturated H* − *h*) 1192.5 − 163.92 = 1028.58 B.t.u.
The heat absorbed by the boiler to make a pound of the superheated steam would, therefore, make

$$1084.18 \div 1028.58 = 1.054\ lb.$$

of the dry-saturated steam, and this multiplied by the water evaporated into superheated steam, which would be all that fed to the boiler (item 19) would give the equivalent amount of water evaporated into dry-saturated steam of the same temperature (item 20).

Item 21. For comparison it is usual to reduce the actual performance of a boiler to the equivalent evaporation from and at 212 deg. This is done by dividing the amount of heat which it takes to make a pound of steam under the actual conditions, $H - h$, by 970.4, the amount of heat which is required to evaporate a pound of water at 212 deg. into dry-saturated steam, of the same temperature. This quantity

$$\frac{H - h}{970.4}$$

is called the "factor of evaporation" and gives the equivalent evaporation from and at 212 deg. of 1 lb. under the conditions for which H and h are taken. Multiplying the quantity actually evaporated (item 20) by this factor gives the equivalent amount evaporated from and at 212.

For our case the gage pressure is 127 lb. (item 9) or

$$127 + 14.7 = 141.7\ lb.\ absolute$$

This corresponds to temperature 354 in the Marks-Davis tables where the value of H is found to be 1192.4. The value of h at the given feed-water temperature 196 deg. (item 10) is 163.92; then

$$\frac{H - h}{970.4} = \frac{1192.4 - 163.92}{970.4} = 1.0599$$

This is the factor of evaporation and multiplying the evaporation under the actual conditions by it we have

$$item\ 20 \times \frac{H - h}{970.4} = 108{,}639.34 \times 1.0599 = 115{,}846.84\ lb.$$

The same formula will apply for superheated steam if H is taken as the total heat **h** of such steam and item 19 may be multiplied directly by the factor of evaporation so found. A table of factors of evaporation for dry-saturated steam of different pressures with different temperatures of feed will be found on pages 369 and 370 of the Mar. 17 issue.

Items 22, 24 and 25 are simply the *total* quantities of dry coal fired (item 16), steam actually made (item 20), and steam which would have been made from and at 212 deg. (item 21) reduced to quantities *per hour* by dividing by the duration of the test (item 7).

$$item\ 22 = item\ 16 \div item\ 7 = 13{,}199.74 \div 12.5 = 1055.98$$

$$item\ 24 = item\ 20 \div item\ 7 = 108{,}639.34 \div 12.5 = 8691.15$$

$$item\ 25 = item\ 21 \div item\ 7 = 115{,}846.84 \div 12.5 = 9267.75$$

Item 23 is the number of pounds of dry coal burned per hour per square foot of grate, and is found by dividing the whole number of pounds of dry coal per hour (item 22) by the number of square feet of grate surface (item 3). In our case

$$\frac{item\ 22}{item\ 3} = \frac{1055.98}{62.5} = 16.9\ lb.$$

Item 26 is the number of pounds of steam, reduced to the equivalent from and at 212 deg., made per hour by each square foot of water-heating surface and is found by dividing the total evaporation per hour under those conditions (item 25) by the number of square feet of water-heating surface in the boiler (item 4)

$$\frac{item\ 25}{item\ 4} = \frac{9267.75}{3500} = 2.65\ lb.$$

Item 28 is an expression of the unscientific but persistent usage of expressing the performance of a boiler in horsepower. The calculation was fully explained in the previous article.

It is generally accepted that the evaporation of the equivalent of 34.5 lb. per hour from and at 212 deg. constitutes a horsepower so the capacity in horsepower may be found by dividing the equivalent evaporation per hour from and at 212 deg. (item 27) by 34.5.

$$\frac{item\ 27}{34.5} = \frac{9267.75}{34.5} = 268.63\ hp.$$

Items 29 and 30 are the builder's rating, which must be got from him. It is much more sensible to rate the boiler directly in pounds of steam which it will make per hour from and at 212 deg., as in item 29, and this practice is being followed more and more by engineer buyers. The horsepower rating is usually computed at 10 sq.ft. of water-heating surface per horsepower.

Item 31. If the boiler evaporates 9267.75 lb. of steam from and at 212 deg. per hour (item 27) and is rated as being able to evaporate 12,075 lb. (item 29 equivalent of 350 hp.) it develops

$$\frac{9267.75 \times 100}{12{,}075} = 76.75\ per\ cent.$$

of its rated capacity, or

If the boiler does 268.63 hp. and is rated at 350, it is doing

$$\frac{item\ 28 \times 100}{item\ 30} = \frac{268.63 \times 100}{350} = 76.75\ per\ cent.$$

of its rated capacity.

Item 32 gives the amount of water which disappeared per pound of coal fired, including the moisture in the steam and the coal.

$$\frac{item\ 19}{item\ 14} = \frac{111{,}654}{13{,}724} = 8.14\ lb.$$

Item 33 gives the number of pounds of water evaporated per pound of dry coal

$$\frac{item\ 20}{item\ 22} = \frac{108{,}639.34}{1055.98} = 10.29$$

Item 34 gives the equivalent evaporation from and at 212 deg. per pound of *dry* coal

$$\frac{item\ 21}{item\ 16} = \frac{115{,}846.84}{13{,}199.74} = 8.78$$

Item 35 is the same quantity again per pound of combustible burned, not per pound of combustible fired, for there will be some of the combustible in the ashpit refuse. The combustible burned is the difference between the weight of the coal fired and that of the ashpit refuse.

$$\frac{item\ 21}{item\ 16 - item\ 17} = \frac{115{,}846.84}{13{,}199.74 - 1238} = 9.68\ lb.$$

Item 36 is best determined by burning a sample of the coal in a coal calorimeter. The valve given here is 12,700 B.t.u. per lb.

Item 37 cannot be determined without knowing the percentage of ash or noncombustible matter in the coal which may be materially different from item 18 on account of the combustible in the ashpit refuse. Assume the percentage of true noncombustible in the coal to be 7.3 per cent. of the weight of the dry coal, then 1 — 0.073 = 0.927 of a pound of combustible would have 12,700 B.t.u., and one pound of combustible

$$\frac{12{,}700}{0.927} = 13{,}700\ B.t.u.$$

Item 38. For every pound of combustible burned under it the boiler made the equivalent of 9.68 lb. of steam from and at 212 deg. (item 35). For each pound of steam it absorbed 970.4 B.t.u. For each pound of combustible furnished, therefore, the boiler absorbed 970.4 × 9.68 = 9393.472 B.t.u., which is

$$\frac{\textit{item } 35 \times 970.4 \times 100}{\textit{item } 37} = \frac{9.68 \times 970.4 \times 100}{13{,}700} = 68.57\%$$

Item 39. For each pound of dry coal which the boiler had supplied to it, it evaporated the equivalent of 8.78 lb. of water from and at 212 deg. (item 34). For each pound of coal furnished, therefore, the boiler absorbed 970.4 × 8.78 B.t.u., and as each pound of dry coal carried in 12,700 B.t.u., the whole outfit, boiler-grate furnace, etc., utilized.

$$\frac{\textit{item } 34 \times 970.4 \times 100}{\textit{item } 36} = \frac{8.78 \times 970.4 \times 100}{12{,}700} = 67.09\%$$

If more of the coal had gone through the grate or if the coal were less completely burned the result would be lower, so that this value includes the efficiency of the grate, while that of item 38, based upon the difference between the coal fired and the ashpit refuse does not.

Items 40 and 41. By dividing item 21 by item 14 we can find how many pounds of steam can be made from and at 212 deg. per pound of the coal as it comes to us. To make 1000 lb. would require $\frac{1000 \times \textit{item } 14}{\textit{item } 21}$. The cost per pound is item 40 divided by the number of pounds in a ton (2000 or 2240, according as the price is given per short or long ton) and multiplied by 100 to reduce to cents. Suppose our price to be $3.60 per short ton the cost of coal to evaporate 1000 lb. of water from and at 212 deg. will be

$$\frac{1000 \times \textit{item } 14 \times \textit{item } 40 \times 100}{\textit{item } 21 \times 2000}$$

$$= \frac{1000 \times 13{,}724 \times 3.60 \times 100}{115{,}846.84 \times 2000} = 21.33c.$$

Feed Heating by Live Steam

By A. Braucher

SYNOPSIS—By citing a few simple experiments to show the rapidity with which boiling water takes up heat and the relative slowness with which cold water absorbs heat, especially when the circulation is impaired, the author argues for the introduction of feed water at boiling temperature into the steam space of the boiler.

⁂

The arguments for and against using live steam for heating feed water are well known. The theorist has failed to make good in his attempt to deny the gain claimed by practical engineers to result from such feed heating because it was in direct contradiction with his theory; he should have amended his theory to agree with the facts. It is the purpose of this article to submit a number of facts, some of which do not agree with what one would naturally suspect from the conditions; also, to deduce a satisfactory theory to explain the gain and saving due to feed heating with live steam.

Water at a temperature of 500 deg. when discharged into the atmosphere from its confining pressure will absorb its own heat so rapidly in evaporating a portion of it and expanding the vapor that a person may stand with impunity within a few feet of and in line with an inch discharge nozzle. The vapor itself as well as the straggling drops of water will feel cool instead of hot.

If the exhaust from an engine is discharged upward into a stack which is open at the top and bottom, much of the exhaust steam will be condensed, and the drops of water descending through the ascending column of mixed air and vapor will feel cool to the hand. This cooling is caused by the steam giving up to the air the heat required to expand the latter to the volume due to the increased temperature.

Gas or air under pressure at an ordinary temperature will absorb heat rapidly upon being allowed to escape into the atmosphere or even into a compartment which is under less pressure. This absorption of heat is sufficient to produce freezing of the contained moisture in the case of air at a temperature of 60 deg. and under a pressure of 60 lb. when exhausted into the atmosphere. The same effect is produced in the natural-gas regions, where the initial pressure of the wells is high and is reduced by means of a reducing valve. Also, where a small quantity of gas is allowed to pass through a valve for use as fuel, the pipe between the valve and the furnace becomes covered with frost. Steam escaping under pressure will absorb its own heat so rapidly that the hand may be held in the escaping vapor at a slight distance from the point of issue without discomfort.

Boiling water absorbs and stores up as latent all available heat of an intensity greater than the degree at which the boiling takes place, depending upon the pressure to which the liquid is subjected. A reduction of pressure will produce an enforced evaporation, and the heat necessary to accomplish it will be absorbed with avidity from the surrounding surfaces or from the body of the liquid itself, depending upon the relative temperature of the two and also of the liquid in contact with the heated surfaces. If that liquid is below the point of evaporation, due to the pressure, evaporation will not take place in contact with the heated plates and the enforced absorption of heat from the heated surfaces will not take place.

It is the evaporation of water and the resulting rapid absorption of heat that makes it efficient in extinguishing fire. If the water could not evaporate, and could only absorb the heat by an equivalent rise in temperature, the water would become red hot in a short time and would be but little better in putting out a fire than so much shot (iron) thrown upon it.

Cold water is a poor conductor of heat, and is heated by convection when the point of application of the heat is below, as water may be boiled for hours by heating from above and remain practically unaffected below; also, ice will not melt to exceed 3 in. below the surface with two hours' boiling at the surface.

A particle of water in evaporating instantly absorbs enough heat to have raised its temperature from 32 to 1000 deg. F. had it continued to exist as water. It is evident that water at 32 deg. cannot possibly absorb instantaneously heat enough to raise its temperature a small number of degrees, even if the plate with which it is in contact were red hot, as witnessed by the spheroidal state of water.

A glass boiler with a flat metallic bottom for the heating surface was arranged so that water could be introduced into pans in the steam space or into the water space in the ordinary way. When cold water was fed into the water space the boiling ceased almost immediately, while it increased perceptibly when fed into the pans in the steam space. The boiler could be removed entirely from the source of heat and remain for some time after it had ceased to boil, when it would boil rapidly again upon feeding cold water into the pans in the steam space.

A boiler that has stood up under heavy service all day will sometimes "bag a sheet" after the engine has been stopped, the feed turned on and the fire banked. This is caused by the sudden change from conditions favorable to the rapid absorption of heat from the heating surfaces to the worst combination of conditions against such absorption. During the day the rapid consumption of steam causes a strong ebullition, keeping the water in circulation, preventing sediment or loose scales from settling on the heating surfaces, and the heat is rapidly absorbed in the evaporation. When the engine is stopped and the feed turned on, ebullition ceases, a layer of sediment settles down on the heating surfaces, causing a rapid accumulation of heat in the boiler plates.

The question now resolves into whether there should be boiling water in contact with the plates and tubes, or water below the boiling point. To have boiling water, live steam must be used to heat it; but it will absorb more heat from the heating surface by reason of its being at the boiling point. With cold water (any temperature below that due to the working pressure of the boiler) in contact with the plates and tubes, we will save the steam necessary to heat it to boiling, but will lose in heat being absorbed more slowly by the cooled water. In the first case, the heat is "pulled" into the water by reason of the enormous demand for heat sufficient to make the change from water to steam, while in the second case the heat is "pushed" into the water in opposition to its nonconducting property.

Other gains from feeding water at the boiling point are the increased circulation, the maintenance of a uniform temperature in all parts of the boiler, and the possibility of removing impurities from the circulating water, thus adding to the power and safety of the boiler and reducing the expense for fuel and repairs.

It is sometimes claimed that the balance or equality of temperature between the water and the steam within the boiler is maintained automatically, some of the water passing into the steam or some of the steam being condensed into the water to make up any excess or deficiency of heat in the one or the other. There is a wonderful capacity for making up any deficiency in the steam space by the evaporation of water, but not so in getting the heat back from the steam into the water. This is plainly shown in connection with the continued boiling of water in one compartment of an air-tight system, when removed from the source of heat, to replace the steam in another compartment in which the steam is being condensed by immersion in a bath of mixed ice and salt. The bulb containing the boiling water will lose its heat rapidly and will feel cold to the hand while the pipe connecting the two compartments is still quite hot, showing that the enforced boiling is at the expense of the heat in the water, cooling it rapidly, even to the extent of freezing it by boiling if the system is entirely freed of air so that the condensation of the vapor will reduce the pressure to a vacuum as the temperature is reduced.

The difficulty of getting the heat from the steam to the water when there is a deficiency of heat in the water is plainly shown by observation of conditions existing in a firebox boiler into which too much cold feed water has been introduced below the water line. Often the water drawn off through the blowoff valve is found to be cold while the steam gage indicates 80 to 100 lb., and the temperature would not become unbearable to the hand until a considerable portion of the surplus water had been withdrawn.

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Venning Improved Sectional Water-Tube Boiler

Interest is being shown in a sectional water-tube boiler manufactured in Canada and designed by A. Venning, Preston, Ont.

In many respects, it resembles the ordinary type of water-tube boiler, but embodies several features designed to improve the circulation and steaming capacity, increase the area for mixing, combustion and travel of the gases, eliminate tube troubles and reduce the cost of maintenance and repairs. It is made of wrought steel to comply with the government regulations.

The circulating tubes between the steam drums and the tops of the rear headers are dispensed with, and, instead, one large circulating pipe, Fig. 1, is used to convey the water from each drum to the bottom of the header sections, thus directing a full supply of water to the lower rows of tubes where it is most needed. The pipe also keeps the tubes well supplied under all conditions and thus insures a constant, rapid and positive circulation.

The forged-steel headers and nipple connections are also larger than usual, so that the steam is provided with a ready means of escape as soon as it is generated. The effect of this mode of circulation will be readily appreciated when it is realized that at least 70 per cent. of the steam is generated in the lower rows of tubes; that with the water flowing in one direction, every tube is brought into action, there being no possibility of short-circuiting in some tubes, with sluggish or even reversed currents in others.

The headers are made of forged steel and so staggered that one tube overlaps the space beneath it. They are of larger section than usual and by having the tube spacing increased with an easier curve of sinuation, provide a greater internal area of waterway and offer a minimum resistance to the flow of steam and water.

The handholes opposite the end of each tube are oval, Fig. 2, being cut out of the solid metal; the tube holes are drilled by the same machine, with no punching work whatever in the manufacture of the headers. The handhole cover plates are placed on the interior with ample clearance between the plates and the header; the joint is made with a thin gasket, bearing on machined surfaces.

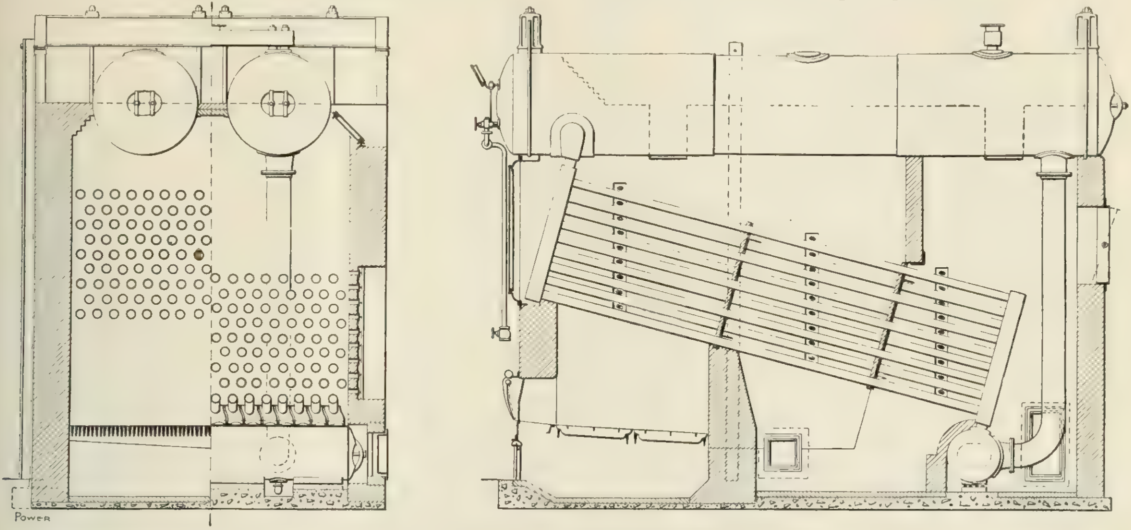


Fig. 1. End and Side Elevations of a New Water-Tube Boiler

The end elevation shows a half section through the furnace and rear pass. The side elevation shows the connections between the drums and the tubes and the rear bottom drum.

The steam and water drums are of large diameter and at the front end of each and riveted to it is a forged-steel cross box, made from a solid plate without weld or seam, the box being connected to the front headers by 5-in. nipples, giving a large discharging capacity.

At the rear of each drum and connected to a wrought-steel nozzle is a large circular lap-welded, steel, downtake pipe, which conveys the water to the bottom of the headers. Both are connected to a 24-in. cross drum at the lowest point of the boiler and in a position remote from the action of the fire and the hot gases. It is made of steel plate, riveted and reinforced at the nipples.

By using a large drum, the velocity of water passing through it is greatly decreased so that the solid material in the water has time to precipitate somewhat. As the points of entry are limited by the number of downtakes, the impurities settle at these points and are drawn off by the blowoff pipe placed beneath each opening. With this reduced velocity and a change in the direction of flow, there is less chance of impurities being swept directly into the generating tubes than if the water had to force its way to the bottom of the headers.

The drum is carried on roller plates, resting on a solid foundation, provision being made for the blowoff pipes to be placed at the bottom. Another feature is that, with double-drum boilers, these large downtakes act as equalizing pipes in maintaining a uniform water level in both drums.

The joints at the flanges of the downtakes suffer no injurious effects from the action of the gases, it is said, no trouble being experienced with the boilers already installed. The pipe, by having an elbow at the lower end, compensates the effects of expansion and of contraction. It is satisfactory in operation, and as the drums are suspended in the usual manner from rolled-steel beams and channels, no weight is brought to bear on this pipe.

The tube center spacing is greater than usual, both horizontally and vertically, giving more room for the mixing and the combustion of the gases, with a larger area in each pass for their travel, so that the baffles can be carried the full depth of the section, thus making the whole of the tubular heating surface effective.

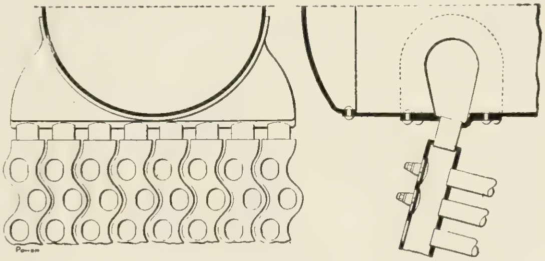


Fig. 2. Arrangement of Header and Spacing of the Tubes

The floor space occupied by this boiler is slightly greater than in many others, on account of the increased spacing of the tubes. As the quantity of water a boiler will evaporate is not directly dependent on the amount of its heating surface nor on the quantity of coal it will burn, but mainly upon its effective circulation, it will be seen that the question of space is offset by other material advantages in the boiler itself.

The boiler can be made with a number of 5-in. downtake pipes, expanded into a cross box at the rear of the drum, or curved and expanded into the side of the mud drum, thus dispensing with the special nozzles and more costly pipe, and at the same time providing a positive circulation throughout.

Superheaters can be attached in the usual way.

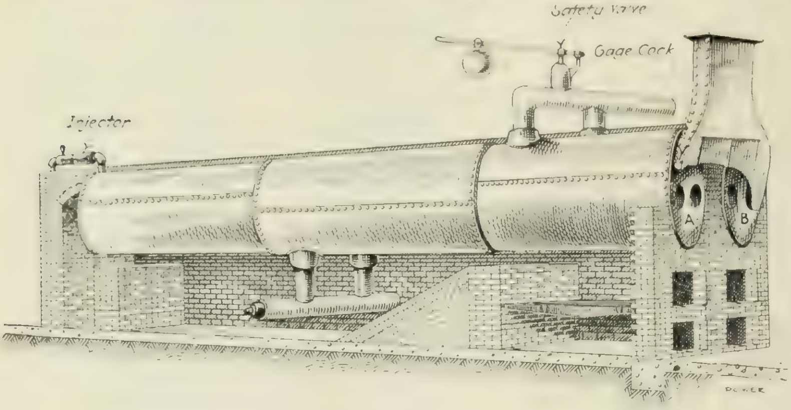
Some Steam Plants!

By George F. Willis

During some 40 years of all kinds of experience, I have seen steam plants run so closely to the ultimate end of things that cold chills ran up my back to be in them. I once walked out of a sawmill in Alabama, after having spent a few minutes there. In that time they were trying to make an injector work, with no water in sight in the boiler and steam blowing off at 130 lb. Before I had gone a half mile the boilers exploded.

Of all the experiences I ever had, the following was the extreme limit. Back in the eighties, my father sent me to a little town in Tennessee to run a sawmill. This mill had been operated by a man who was put down as a sawmill expert in that section. As a matter of fact, he had been successful in producing lumber, as success and mills went in those days.

This was considered a big mill. The boilers, which were supposed to have come from England originally, had been taken out of a Mississippi River steamboat after many years' service. They were 40 in. in diameter by 30 ft. long, each had two 14-in. flues, and were connected together below by what was called a "standpipe," although I have no idea where the name originated. This device consisted of a U-shaped cast-iron pipe with about a 2½-in. opening. Each of the legs was connected to a boiler, and from the bottom of this pipe, in either direction, led a connection of the same size, running through the boiler walls. The water supply was supposed to be put in through the left-hand end of this connection, while the blowoff valve was on the other end. The blowoff valve and connection was in place all right. fortunately, as will be seen, but—as there was no feed pump—the other end was blanked!



Sawmill Boilers

The feed water was supplied to the boilers by an injector, which had been piped into the back end of the left-hand boiler. On this same boiler, on the front end, was one solitary gage-cock, the others having long since been broken off and the holes filled with iron plugs. The two boilers were connected above by a cast-iron pipe similar to the one described, having two openings, one for the steam line to the engine and the other for a safety valve.

With two boilers so connected and fed through one of them (call it *A*), if the other (*B*) got any water, it had to go down the leg from boiler *A* and up through the leg into *B*. There was nothing whatever to show the water level in boiler *B*, and only one gage-cock on *A*.

I asked the "engineer" how he knew where the water level was. He said if it "showed," he cut off the injector, and if it did not he started it. As there was no steam gage, I inquired how he told what the pressure was. He said if the engine "pulled" all right, he knew he had enough; if it did not, he fired up!

Although an inexperienced boy, I knew this would not do, so I got some gage-cocks, three for each boiler, and after a day's work drilling out the iron plugs and threading, I got them placed. Then I put on a pressure gage, but, as I remember it, I used the old opening on top of boiler *A* for this. Next I started to get up steam.

At about 30 lb. pressure I went around to the blowoff valve on boiler *B* and opened it. All I could get was blue steam. I had the fire pulled at once, and when the boilers were cooled down, I took out the manhole plates in the back ends of the boilers, and looked in. Boiler *B* had no water at all, and the U-pipe connection from boiler *A* was entirely stopped up by scale and rust. There was no opening to be seen.

I got this cleared out, and started the fires again. At about the same pressure as before, with a long stick, I raised the lever of the safety valve. This was a long-weighted lever with a cast-iron ball on it as large as a man's head. I lifted the lever and ball all right, but no steam blew out. I pulled the fires again, and investigated. Evidently some time the valve had leaked, and the "engineer" had poured 25 lb. of melted babbitt on top of the valve to stop the leak.

The engine, which was 14x24 in., had no governor and was controlled by what we then called a "sawyer's" valve, which was really a pivoted disk in the steam line. When the sawyer pulled this valve wide open, the engine did the best it could with the load.

He usually speeded the engine up to about what he thought it would stand, and plunged the saw into the cut. I am willing to gamble that the rim of the engine wheel had many times exceeded all safe limits, and that, theoretically, it should have burst long ago. I put on a fly-ball governor; the men did not think much of it.

The boilers were of the softest and most ductile iron. I remember well how this iron cut and looked. The boilers had been in use for years before doing duty in the sawmill, and the mill had been run years and years in different locations before I ever saw it. What pressures the boilers had been under is a wild guess. Just guessing will never come within a half mile of the truth!

All this is absolutely true and unexaggerated.

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Coal Briquettes to the amount of 181,859 tons, valued at $1,007,327, were manufactured in 1913, according to Edward W. Parker, of the U. S. Geological Survey. Compared with 1912, there was a decrease of 17 per cent. in tonnage, but an increase of 5½ per cent. in value.

Editorials

Uncle Sam's Home-Made Current

On other pages of this issue are given the operating data of the Chicago Federal Building plant, and an estimate is made of the saving effected by the installation of generating units to supply current for power and lighting. The building had ample capacity in boilers which were installed to supply steam to elevator pumps, air compressors, miscellaneous machinery and to the heating system, as the supply of exhaust steam only fulfilled about one-half the demand for heat in the colder weather. It was a simple matter to install engine-driven generators which would reduce this steam to the proper pressure for heating and at the same time generate all the current that was needed for light and power.

The advantage of such an arrangement was apparent, and government officials selected to investigate, estimated an annual saving of at least ten thousand dollars over buying current. Notwithstanding, it required years of agitation to overcome powerful political influence brought to bear and a reduction in rates tendered by the central station. When the matter was brought to the attention of the present administration, the installation of an isolated plant was sanctioned, and the results obtained in the first month's operation vindicate the decision made at Washington.

The plant has exceeded expectations. Running under adverse conditions at the start, it has made a saving of seventeen hundred dollars for the month of March as compared with the same month of last year. Due to delay in installing a meter, no records are available on the actual steam consumption of the engines, but meters installed for the other departments showed that more steam was generated, excluding that taken by the generating units. The temperatures were nearly the same and the cost of coal varied only four cents per ton. Under these conditions the difference in total operating expense was the foregoing figure. With the operating conditions improving, as they will, the saving should be greater. In the months colder than March, when more steam is required for heating, there is every reason to expect a larger gain, although this will be offset by a reduction during the warm weather.

The estimate in the article of an average saving in operating expense of eighteen hundred dollars for six months and six hundred dollars per month for the balance of the year, is conservative, and it would not be surprising if the year to come showed results in excess of the estimate. On the above assumptions the annual saving amounts to more than fourteen thousand dollars, and deducting the usual percentage for interest and depreciation leaves a net balance exceeding ten thousand dollars, which is 23.5 per cent. of the total investment.

From the data given in the article the kilowatt-hours generated averaged 4366 per day. Dividing this by twenty-four, gives 182 kilowatts as the mean load, although at times the maximum demand exceeded 300 kilowatts. It is evident that the electrical load is small for so large a saving, but it only shows what can be done when there is a heating system of sufficient capacity to utilize all or the greater part of the exhaust steam. The efficiency of the combination is approximately sixty per cent.—that is, this percentage of the heat in the coal is used as compared to five to ten per cent. in a noncondensing engine exhausting to atmosphere.

It is surprising how many buildings in Chicago, and other cities for that matter, buy their current. Many of them have boilers for heating, and their electrical load will average as much, if not more, than that of the Federal Building. The coal and ash nuisance cannot be advanced, for they must have coal for heating and but little more will generate the current as well. Unless the owners are given a rate much below what the central station can charge without discriminating against the greater part of its customers, an uptodate generating plant will save them money. What the rate should be to make purchased current desirable may be estimated from the large saving effected in the Federal Building, which was charged 1.9 cents per kilowatt-hour and only 0.9 cent for any current in excess of 100,000 kilowatt-hours per month.

The authorities at Washington are to be congratulated on their insight and the vindication of their belief in a private plant. In Chicago, the Federal Building should serve as an example, showing others what they might do in their own buildings and suggesting an investment which will pay big dividends.

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Influence of Volatile Matter on Combustion

The paper on the "Influence of Volatile Matter on Combustion," printed elsewhere in this issue, is of interest in this day of general investigation into methods of burning low-grade fuel and into the design of boiler furnaces.

A furnace with an arch over the fuel bed extending from the bridge-wall to the front wall so assisted in producing high furnace temperature that the rapid distillation of the volatile matter from green coal produced objectionable smoke in large volume. To reduce the quantity emitted in a given time, part of the arch was removed, exposing more of the heating surface to the gases.

On first thought, this seems contrary to correct practice, for it is generally conceded that hot surfaces are most essential to prevent smoke. They are. In this case, however, the nature of the coal was such that its rapid distillation was caused by the heat radiated from the full arch. By exposing more of the heating surface, thus reducing the furnace temperature, the rate of distillation was decreased sufficiently to drive off the gases in volumes small enough to be more or less thoroughly mixed and burned before condensation in the comparatively cool boiler and flue. It would seem that the same result—i.e., the elimination of dense smoke at high rates of distillation—could be accomplished by using higher settings or greater furnace volume with the full arch. Then there would be a greater area of hot surface with which the gases could make contact and more available space in which to allow the flame to burn out.

Burning high volatile coal successfully is not alone a question of furnace temperature, but of gas volume, gas mixture, furnace volume, temperature and time. For a given furnace with certain facilities for mixing the gases, smoke will be produced if the rate of distillation is high. This rate will be higher, the greater the furnace temperature.

The difference in velocity at which the gases pass through the furnace compared to that at which they are driven off during the distillation process, should be great to allow sufficient time for all the gases and the air to become adequately heated and mixed.

It is gratifying to know that this government is conducting investigations into the burning of high-volatile coals in hand-fired furnaces. Goodness knows there is an urgent need for such knowledge among those who have most to do with the combustion of such fuel.

Removing Obstructions to Business

Under this significant title, a writer in the *Electrical World* discusses the methods of a central station in its campaign of aggrandizement. The article deserves to be commended for its frankness, if nothing else.

After saying, in effect, that by offering a tempting rate, it is easy to sell current where a plant has not yet been installed, the author explains that the real problem is how to induce the prospective customer to scrap, shut down or sell it, when he already has power-generating equipment. Those who offer the principal difficulty are the ones who will not make a change until they have realized something on their investment in plant, so the enterprising company referred to has established a department to buy in old engines as cheaply as possible, sell them at as near the purchase price as possible, and charge the loss to the cost of getting new business. On a total of 123 engines purchased and resold in nineteen months, the average loss was $22 engine—"not a large amount when placed alongside the estimated annual income" from the current sold.

Now comes the interesting part, the disposing of old engines. To quote from this highly enlightening report: "The engine-selling department advertises engines for sale in papers which circulate in the communities it is desirable to reach." (In other words, where current is not for sale.) "Advertisements are not inserted in the company's name. It not infrequently happens that a prospective purchaser of an engine who is on the company's lines will be induced to change his mind and sign an agreement for electric service to do the work an engine was originally intended to do. When a man calls to inquire about an engine, the first question he is asked is where he wants to use it. If his location is beyond the company's sphere of influence, the negotiations proceed. If within the territory supplied with service by the company, the negotiations stop right there and then. No engines are sold by the department where the company's electric service may be obtained." How naive! What business acumen this organization displays!

This policy may be set down as shrewd. So is that of selling shoddy, half cotton goods for all wool, or any other merchandizing that deceives successfully, but it is not honest. And it is not professional. It is to just such unprincipled methods of promoting central-station business that we are unalterably opposed. As we have said repeatedly, there is a sufficient legitimate field for the central station to make recourse to any questionable practices unnecessary. The alarming revelation is that such a raw proposition can be boldly exploited in public print, apparently without fear of arousing the disgust and condemnation of a people who pride themselves in a love of fair play. It is high time that those who are jealous of the good name of American engineering resented such insults.

Gravity Delivery of Coal

While gravity delivery of coal into power-plant yards has recognized advantages, the saving per ton in the cost of handling fuel in this way, as compared with mechanical or hand trimming, depends upon many factors. Chief among these are the amount of coal storage required, the difference in level between coal yards and side tracks, and the amount of fuel to be handled in a given time. The cost of track elevation and of placing coal cars at the desired level for economical dumping must, in many cases, be considered when comparing mechanical delivery with gravity dumping.

In a recent instance, an analysis of the fuel-handling problem showed that the delivery of coal by gravity from cars on a track fifteen feet above the yard saves the operating company from fifteen to twenty cents per ton as compared with the fixed and operating charges on a fifteen-thousand-dollar coal-handling plant which would otherwise be needed. If there were no difference in elevation between yard and track, and if no plant were installed for handling the fuel, the investigation showed that the cost of trimming the coal by hand from cars into the yard would run from twenty-five to thirty cents per ton. The company uses about thirty-five hundred tons of coal annually.

These differences are important and indicate that in the study of such problems and deduction of unit handling costs for plants of various sizes and designs, the engineer of analytical bent will find much that is interesting and profitable.

The Pity of It!

Regardless of whether a war is justified or not, or which side, if either, is in the right, both sides are always punished; and usually disinterested noncombatants suffer as well. War cannot always be avoided and, perhaps, more times than not, eventually proves to be of real good to humanity. Nevertheless, it is an economic waste in several ways. The cartoon in this issue brings out one of these ways—the hindrance of engineering and industrial progress—which is generally lost sight of in the contemplation of war's more horrible consequences, the cost in lives and property destroyed.

Correspondence

Backfiring through Intake

Mr. Demorest's statement in the Feb. 14 issue, that a rich mixture will backfire in the manifold is entirely contrary to my experience. The statement should hold true, according to his reasoning, that the charge hangs fire during the expansion and exhaust stroke; it does not work out in practice.

He also states that it is a common mistake to attempt to distinguish between an over-rich and an over-lean mixture. This might have reference altogether to an automobile engine, which would hold true only when the engine was running idle. If the throttle were suddenly opened with an over-rich mixture, the engine would miss and fire in the muffler. The difference is quite noticeable on a stationary gas or gasoline engine.

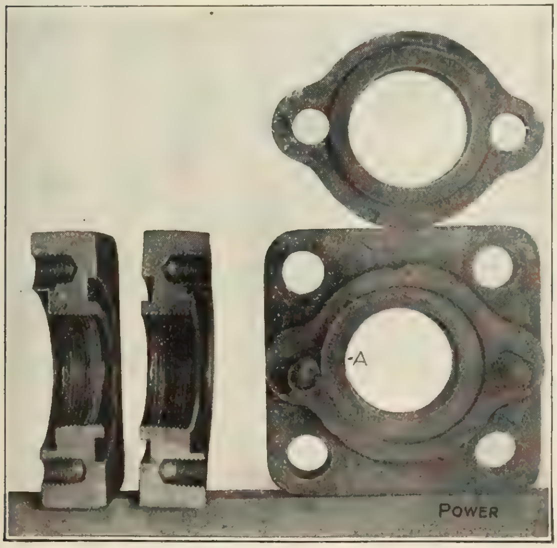
N. E. Woolman.

Kittanning, Penn.

* * *

Stopping an Ammonia Leak

After cleaning and overhauling a small refrigerating plant and recharging the system, it was discovered that there was a small ammonia leak on one of the 2-in. flanges on the separator leading to the condenser. As tightening it did not stop the leak, the flange was uncoupled and a new gasket put in. After trying again it still leaked, and upon close investigation it was noticed that the flange appeared to be slightly curved. Scraping around the stud at *A* of the packing gland it was found that the flange was cracked and would not tighten evenly all around. The flange was then replaced by one without a gland. After this side was repaired and the pressure applied to it the flange on the opposite side of the separator showed the same trouble, and on trying to tighten it, a crack appeared in that one also.



Showing the Cracked Flange

After this was repaired I removed the ⅝-in. studs and sawed through the solid side of one of the flanges, the two halves showing in the left of the illustration, which shows the flange to be poorly designed. The stud holes appparently weaken the flange at those points. No further trouble was experienced with the solid flanges that replaced them.

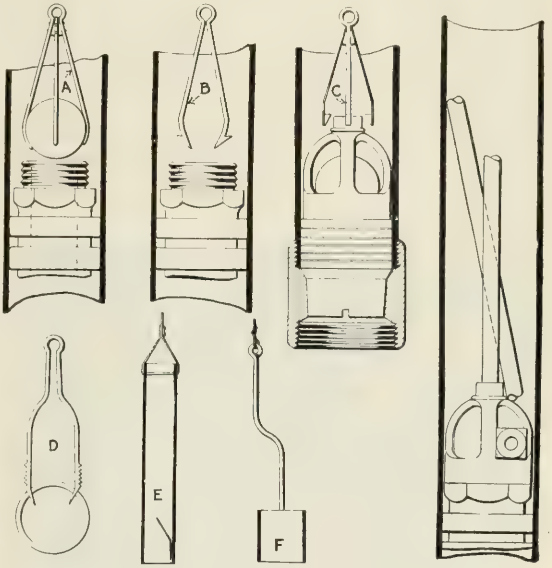
L. M. Johnson.

Emsworth, Penn.

* * *

Troubles with Deep Wells

Our driven wells are several hundred feet deep and water is pumped with a deep-well and a one-geared pump; the cylinders are at a depth of 275 ft. The sucker rods are 2¼-in. size and the plungers are single acting, of the ball-valve type. When anything goes wrong 275 ft. down, one has his work cut out, especially if there is but one source of water supply.



Tools Used in Deep-Well Repairs

The illustration shows how the bonnet pulled from the plunger leaving the ball on top. The threads of the bonnet were stripped so a tool was made to get the ball, as shown at *A*. Then the tool shown at *B* was made and used to get the rest of the fitting.

At another time something got under the ball of the foot valve and in trying to pull it in the regular way the spud broke, but was finally got out with the tool shown at *C*. The tool *D* was made to get the washer rings out when the lower bonnet came off with stripped threads, and the rest of the valve was removed by using the tool *B*.

Once the entire end of the cylinder stripped and the foot valve went to the bottom of a 600-ft. well. A heavy gin pole was erected, two heavy double blocks and some 1¼-in. rope were obtained, and four horses were used to pull the pipe up, using the tool *C* to clutch the cylinder. The valve was fished from the bottom of the well and the ring riveted back on the bottom of the cylinder. We then put everything back only to lose it again and then had to put on a new cylinder.

At another time the rods broke at the crosshead, the nut from the pin dropped to the bottom and the rods broke again 10 ft. down. This piece went to the bottom also. The piece of rod was got out with a short length of 3-in. pipe with a flat spring arranged inside, as at *E*. A nut which was left loose kept catching in the space between the ends of the pump pipe at the couplings. After making a magnet and failing to get the nut, because the nut became magnetized and would stick to the pipe, a piece of stove pipe *F* was arranged to fit inside the 6-in. pipe, and slip down over the nut. Then a piece of 1-in. pipe with a flat spring was let down over the rods and the whole pulled up together. The piece of stove pipe kept the nut from falling over as each coupling in the pipe was passed.

C. A. Scott.

Wales, Wis.

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Gas Explosion in Muffler Pit

Few people realize the explosive power of gas when mixed with a sufficient amount of air. A man who handles dynamite is following a hazardous occupation, and engineers in charge of gas engines go on day by day handling or dealing with an explosive that is almost if not altogether as dangerous.

Result of the Explosion

This force, when properly applied to the piston, is tamed down sufficiently to be turned into useful work, but let something go a little out of the ordinary, as, for instance, a certain amount of gas gets by the engine and finds its way into the exhaust pit, as it did in this case. Then when a spark gets to it, the results are as illustrated.

The engine had been shut down over Sunday and gas had accumulated in the muffler, or found its way through while the engine was being started. Three or four attempts were made before the engine fired. Then there was a violent explosion in the muffler, the concrete cover was thrown every which way, and the wall over the pit was cracked. The engine was not damaged, and was run through the week without a cover on the pit. The window was raised and canvas put in to keep the vibration set up by the exhaust from breaking the glass.

Coffeyville, Kan. P. A. Gett.

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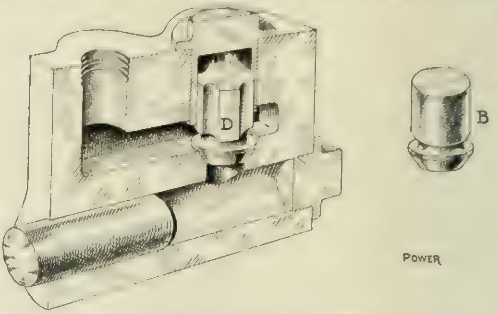
Repairs Should Duplicate Originals

Mistakes in making repair parts and failure to observe closely and duplicate the originals often cause annoyance and loss. For example, a new discharge valve was needed for a pump used for hydraulic elevator service. The repair shop apparently got out a nice job on the new valve and the upper cap, but the guide stem *B* was made round and fitted closely in this cap, so that when the pump was started after the new valve was put in, it worked a few strokes, and then failed, because the valve would remain open, or up in the cap, on account of not having vent around the stem to equalize the pressure. The old valve had flutes cut in the stem, as shown at *D*. After two slots were filed in the new stem, there was no further trouble.



Old and New Valves

C. R. McGahey.

Baltimore, Md.

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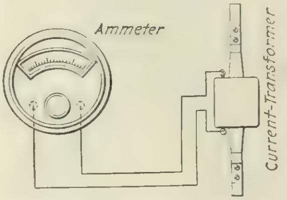
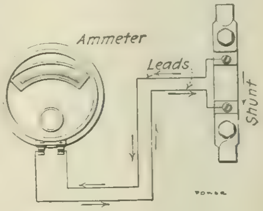
Ammeter Trouble

An ammeter that would itself carry the total current to be indicated for large generators, would be prohibitive in size. Accordingly, it is customary to have the ammeter carry only a small proportion of the current that it indicates, but the scale is marked as if the whole current were going through the meter. In alternating-current work, this is accomplished by means of a current



Ammeter Connections for Alternating-Current Circuit



Ammeter Connections for Direct-Current Circuit transformer, as indicated in Fig. 1. In direct-current work, a low ohmic resistance is cut into the circuit the current of which is to be measured; the ammeter being connected in parallel with this resistance. The proportion of the current taken by the ammeter depends upon the resistance of itself and leads as compared with that of the shunt. This being true, lead resistance is as important in fixing the ratio of current division as is ammeter resistance and only leads of a certain resistance will permit correct indications on the meter.

In a case in mind, a short-circuit behind the switchboard, burned the coiled-up ammeter leads so that they had to be replaced. An equal length of silk-covered lamp cord was used to replace them; but its cross-section was so much greater than that of the original leads, that the ammeter indicated about 40 amp. high, a difference that the engineer noticed because he knew what the load should be when certain switches were closed.

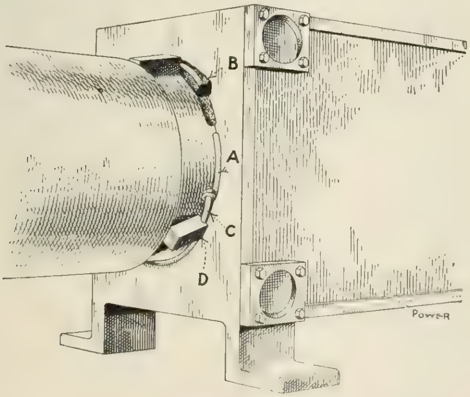
To check his conviction, he cut the ammeter into series with another one which he knew to be about right. With a steady current flowing through both meters and their shunts, he lengthened the faulty leads and found that this decreased the error; so he got a longer piece of the same cord, skinned it for an inch or so at intervals of a foot, to make trial connections easy, and by trial found the length that would cause the two meters to indicate the same; he then tinned the ends, flattened them with a hammer and drilled them to make a terminal and permanently connected them; and everything was all right. When the leads were too low in resistance, the ammeter took more than the proportion of current for which its scale had been made, so the scale was useless unless the error was known.

J. A. Horton.

Schenectady, N. Y.

Leaky Cylinder Joint

The crank-end cylinder head on the high-pressure side of a 30 and 60 by 54-in. compound engine began to leak soon after the engine was erected. The leak extended about one-third of the way around the head, and also showed under the nuts. To repair it by removing the cylinder would have been quite a job, and tightening the nuts would not stop it.



Joint Clamp

The bolts joining the cylinder to the frame were on the inside. A small groove was chipped around the edge of the flange and a copper wire calked into it, as at *A*, and overlaid with asbestos wicking, at *B*.

A ½-in. rod *C* was bent to encircle the frame, having an eye in one end through which the other end passed, to be drawn up with a nut.

Three small spanners *D* were used to force the rod up against the head, by driving them in between the shoulder of the frame and the rod. The illustrations show the parts all assembled ready to be tightened, and after the job was done. Drawing up the nut so that the rod was drawn tightly around the flange, and at the same time driving the spanners, resulted in forcing the asbestos tightly into the corner.

After the nuts were taken off and cupped out in a lathe and replaced with asbestos wicking wraped around the bolts, the job was a success. It required but little time and practically no expense. Copper wire is hardly necessary, as the wicking would fill the space just as effectively. The writer has often made use of this method in stopping leakage around bolts.

Joseph Stewart.

Hamilton, Ohio.

V-Block Belt Cures Slipping of Governor Drive

Fig. 1 shows the design of a troublesome governor drive, due to slipping and breaking ropes, jumping out of their grooves, getting crossed and tangled. Furthermore, it was next to impossible to keep all of the ropes under the same tension, due to stretching.

Rawhide and other kinds of ropes were used, but while the rawhide rope gave the most satisfactory service, it did not prove reliable.

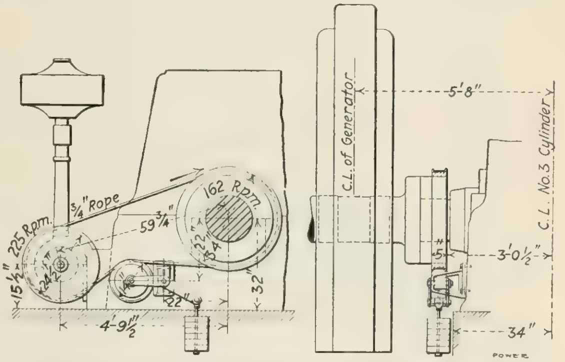


Fig. 1. General Design of Governor Drive

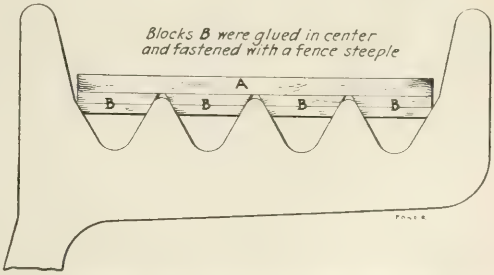

Blocks B were glued in center and fastened with a fence steeple
A
B
B
B
B
Power

Fig. 2. How the Belt Was Made to Fit the Pulley

To make the governor drive reliable, a belt *A*, Fig. 1, was cut 3¾ in. wide. Strips of belting were then cut, with beveled edges to conform to the grooves in the pulleys, on a band saw having a tilting table.

These strips B, Fig. 2, were cut into pieces 1½ in. long and glued to the belt. Each was then secured permanently by a wire fence staple sufficiently long to just reach through the block and belt and be clinched. The belt is thus kept pliable. There were no blocks at the ends, but they were used at the joint to complete the belt. The idler grooves were filled with babbitt and turned down. This belt has been giving satisfactory service, and did not cost much.

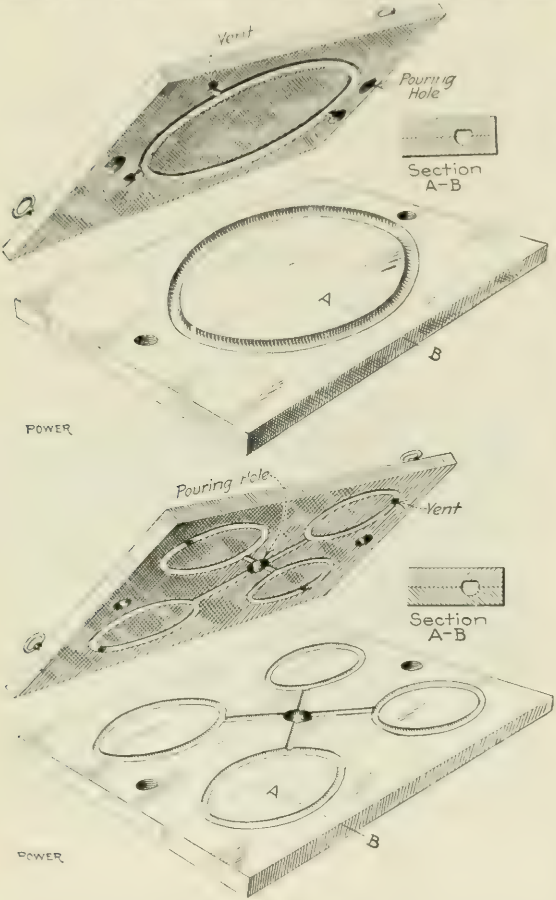
W. G. Webster.

Kittanning, Penn.

*

Lead Boiler Gaskets

The cost of gaskets of all sizes for boilers can be materially reduced by making them of lead at the plant and using the old lead over again in molds as shown. The molds are of cast iron with a milled groove of the desired size and shape in one plate, usually a half-round cross-section; the other may be only a flat plate held in place by dowels and capscrews. A ladle and a forge com- cross-section; the other may be only a flat plate held in made up by new pig lead, which costs about seven cents per pound. About 60 per cent. of the old is recovered, so that the cost of new joints is not excessive. Two men can make several hundred in a day.



Gasket Molds

These gaskets give excellent results when put into service. They are soft and easily tightened if leaking starts, which sometimes happens when the boiler is first fired up. The writer has seen lead gaskets used on the rear end of a Heine boiler, which when cold permitted the nuts on the tube caps to be turned by hand; but the joints did not leak after the boiler was fired up again.

One plant of about 5000 hp. has 350-hp. Stirling and 150-hp. Heine boilers carrying 165-lb. steam pressure, with 100-deg. superheat, on which all hand and manhole gaskets are lead and molded in the plant. They were ⅜ in. thick, ⅞ in. wide and ⅜x½ in. respectively. The plates are easily made where a milling machine can be used.

J. C. Hawkins.

Hyattsville, Md.

*

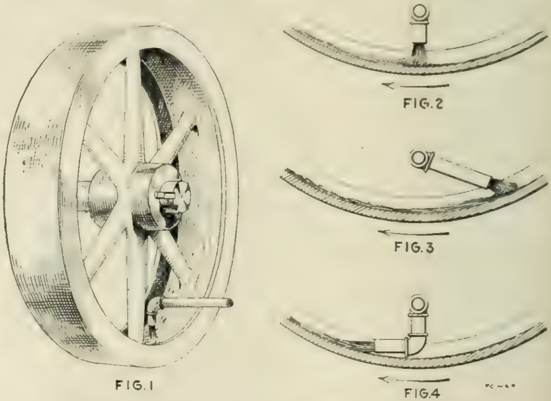
Cooling Prony Brake

An item commonly overlooked in testing steam engines, motors, etc., with a prony brake is the kinetic energy which the brake wheel imparts to or receives from the cooling water.

For example, in a brake test of a 50-hp. steam engine where 1000 lb. of water is used per hour for cooling the brake wheel, if the cooling water is discharged into a trough-shaped rim of brake wheel in about the manner indicated in Figs. 1 and 2, some of the energy will be absorbed in bringing the water up to the velocity of the rim. On the assumption that the rim velocity is a mile a minute, or 88 ft. per sec., it may be seen from the formula

$$\tfrac{1}{2}\,Mr^2 = ft.\text{-}lb.\ per\ sec.$$

that the retardation would amount to about $^1/_{20}$ of 1 hp. To deliver the water in direction contrary to that of motion of the rim, as shown in Fig. 3, the retardation would be greater, depending on the velocity of the water and roughness of the wheel. Though this would be small as compared with the entire output of power, it is evident that for elimination of these errors, the water should be applied as indicated in Fig. 4—i.e., in the direction of motion of the wheel, and, as far as possible, the water should have the same velocity as the rim of the wheel. It is also evident that no method should be used for scooping out the water that would tend to retard the brake wheel.



Methods of Applying Cooling Water

New York, N. Y. S. F. Wilson.

Inquiries of General Interest

Lap and Lead—What is meant by lap and lead of a D-slide valve?

C. F.

Lap of a valve is the distance which it overlaps the port when the valve is in its middle position. Lead is the distance which the valve has uncovered the inlet port when the piston has reached the end of its stroke.

Wider Strap of Double-Strap Joint on Inside of Boiler—In an ordinary butt and double-strap boiler joint, why is the wider strap placed on the inside of the boiler?

T. J. L.

In butt and double-strap boiler joints, as ordinarily designed, the pitch of the outer rows of rivets is too great for a calking pitch; and as calking is done from the outside of the boiler, the wider strap is placed on the inside and suitable calking pitch of an inner row of rivets is utilized for the calked edges of a narrower strap placed on the outside of the boiler.

Electrical Conductivity of Aluminum—What is the relative electrical conductivity of aluminum and of copper wire and the relative cost for equal conduction?

E. S. C.

Hard drawn aluminum wire, 98 to 99.75 per cent. pure, has a conductivity of 55 per cent. to 64 per cent., copper being taken as 100 per cent. Aluminum wire of 62 per cent. conductivity is the generally accepted standard and when of that conductivity and purchased at 2.13 times the price of copper per pound, will give the same length and conductivity for the same expenditure.

Increasing Thickness of Babbitting—How would increasing the thickness of the babbitting of a pair of eccentric straps and use of thicker shims affect the lead of a direct-connected slide valve?

C. S. F.

The effect would be the same as increasing the length of the eccentric rod or of the valve rod, i.e., the valve would have more lead on the crank end and less lead on the head end of the cylinder, but all the events of the valve action would be restored by shortening the length of eccentric rod or of the valve rod by the amount of thickness added to the eccentric-rod babbitting.

Altitude Indicated by Water-Pressure Gage—What variation of depth of water in a tank will be due to a difference of pressure of 5 lb. per sq.in. shown on a pressure gage connected with the discharge pipe from the tank?

E. P.

To eliminate errors due to losses of pressure from friction of water flowing in the discharge pipe, the pressure readings should be taken when there is no flow taking place in the pipe to which the gage is attached. At ordinary temperatures of the water each pound difference in pressure would indicate a difference of 2.309 ft. and a difference of 5 lb. would indicate

$$5 \times 2.309 = 11.545 \text{ ft.,}$$

or about 11 ft. 6½ in.

Coal per Horsepower-Hour—In a plant where the weekly consumption of coal for the generation of power amounted to 40,407 lb., one engine (a) ran 15 hr. developing an average of 132 i.hp., another engine (b) ran 32 hr. developing an average of 78 i.hp., and a third engine (c) ran 55 hr. developing an average of 112 i.hp. How much coal is used per horsepower-hour?

During the week there would have been developed

By engine a 132 × 15 = 1980 hp.-hr.
By engine b 78 × 32 = 2496 hp.-hr.
By engine c 112 × 55 = 6160 hp.-hr.

and the total development was 10,636 hp.-hr. Therefore, the coal used was

$$\frac{40{,}417}{10{,}636} = 3.8 \text{ lb. per hp.-hr.}$$

Radiating Surface of Steam Pipe—How many lineal feet of 1- and 1¼-in. steam pipe are required for 1 sq.ft. of radiating surface?

E. A. B.

Commercial 1-in. pipe has an outside diameter of 1.315 in. and an outside circumference of

$$1.315 \times 3.1416 = 4.131 \text{ in.}$$

hence for 1 sq.ft. of radiating surface

$$\frac{144}{4.131 \times 12} = 2.905 \text{ lin.ft.}$$

of 1-in. pipe is required. Commercial 1¼-in. pipe has an outside diameter of 1.66 in. and an outside circumference of

$$1.66 \times 3.1416 = 5.215 \text{ in.}$$

Therefore, for 1 sq.ft. of radiating surface,

$$\frac{144}{5.215 \times 12} = 2.301 \text{ lin.ft.}$$

of 1¼-in. pipe is required.

Steam from a Cubic Inch of Water—How many cubic inches of dry steam can be evaporated from a cubic inch of water at 62 deg. F.?

W. C. C.

The volume occupied will depend on the pressure. A cubic foot of water at 62 deg. F. weighs about 62.36 lb. and referring to Mark's and Davis' steam tables it may be found that the density of a pound of dry steam at 14.7 lb. absolute or atmospheric pressure is 0.03732 lb. per cu.ft.; at 65 lb. absolute, or about 50-lb. gage pressure, the density is 0.1503 lb.; and at 115 lb. absolute, or about 100 lb. gage pressure, the density is 0.2577 lb. per cu.ft.

Therefore, when 1 cu.in. of water at 62 deg. F. is evaporated into dry steam there will be formed

$$\frac{62.36}{0.03732} = 1670.9 \text{ cu.in.}$$

of steam at atmospheric pressure;

$$\frac{62.36}{0.1503} = 414.9 \text{ cu.in.}$$

at 50 lb. gage pressure; and

$$\frac{62.36}{0.2577} = 241.9 \text{ cu.in.}$$

at 100 lb. gage pressure.

Locating Pulleys and Floor Holes for Quarter-Turn Belt—How may the locations of pulleys and belt holes in floors be determined to transmit power by quarter-turn belt from one horizontal shaft to another at right angles to it?

G. W. E.

Locate a point on each shaft plumb with the center line of the other shaft. The middle of each pulley is to be placed to one side of the plumbed point on its shaft a distance equal to the radius of the pulley on the other shaft, and each pulley is to be located in direction away from the plumb point on its shaft which will be the same as the direction of rotation of the farthest side of the other pulley. It must be borne in mind that the belt is to pass from the top of the upper pulley over the farther side of the lower pulley and around its lower side, and thence to the farthest side of the upper pulley and over it. Knowing the direction to be taken by the belt, the belt holes in a floor can be laid out by a scale drawing or their location can be determined by stretching a line around the pulleys in the direction to be taken by the belt, and finding by trial and error the direction and location required for small holes bored through the floor which admit of free passage of the line when stretched over different parts of the faces of the pulleys. The clearances required for the pulley side of the belt are thus shown and from them the floor holes are readily located and determined with due allowance for thickness, flaring and waving of the belt.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necesary to guarantee the good faith of the communication and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--VI

LAST LESSON'S ANSWERS

21. Consider the point B as a free body. In Fig. 22 let the line AC represent the total vertical load = $(P + W)$ = 1200 lb. The line BC drawn parallel to the rod BC will represent the tension T in the rod, and AB drawn parallel to the strut AB will represent the compression R in the strut. The angle CAB being 40 deg. and the angle ACB 60 deg., the angle CBA must equal $(180 - 60 - 40 =)$ 80 deg.

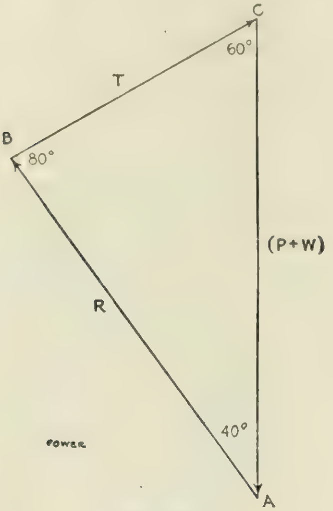


FIG. 22.

From the law of sines

$$\frac{T}{sin\ 40°} = \frac{(P + W)}{sin\ 80°}$$

or

$$T = \frac{(P + W)\ sin\ 40°}{sin\ 80°} = \frac{1200 \times 0.643}{0.985} = 783\ lb.$$

22. Again applying the law of sines there results the equation.

$$\frac{R}{sin\ 60°} = \frac{(P + W)}{sin\ 80°}$$

or

$$R = \frac{(P + W)\ sin\ 60°}{sin\ 80°} = \frac{1200 \times 0.866}{0.985} = 1055\ lb.$$

23. The reaction counteracting the tension T is the strength of the rod which is dependent upon the size and material of the rod. Likewise the strength of the strut AB produces the necessary reaction to counteract the thrust R.

24. In Fig. 23 draw the forces P_1, P_2, P_3 and P_4 with the directions and magnitudes given in problem 10. Draw the force P_5 equal and opposite to the resultant which was found to be 144 lb. Starting with the point O and using the force P_5 as a base line draw a force polygon, making OA equal and parallel to P_5; AB equal and parallel to P_1; BC equal and parallel to P_2; CD equal and parallel to P_3; and the line OD equal and parallel to P_4.

25. All the forces must be in equilibrium since they can be represented by the sides of the polygon $OABCDO$ taken in order. If the line OD does not come out equal and parallel to the force P_1 there has been an error somewhere in the student's work.

PARALLEL FORCES

Parallel forces are those which act at different points of a body and have their lines of action parallel. If the forces act in the same direction they are called *like forces;* and if they act in opposite directions they are called *unlike forces.* The resultant of two like forces is equal to the *sum* of the forces and *acts in the same direction* as the forces; the resultant of two unlike forces is equal to the *difference* of the two forces and *acts in the direction of the greater force.* In the case of like forces the resultant will lie between the two forces and in the case of unlike forces the resultant will lie outside of both forces. The above laws are almost axiomatic, or self-evident, and no proof will be given at present.

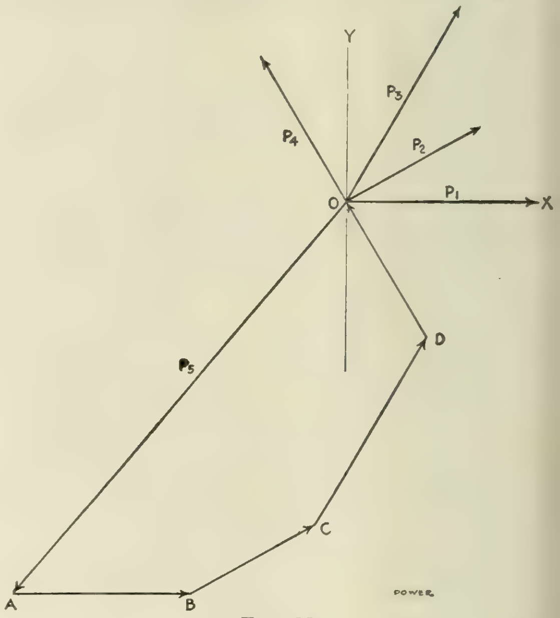


FIG. 23.

Parallel forces are simply an extension of the parallelogram law in which case the point of meeting of the forces is at an infinite distance from the body on which the forces are acting. In Fig. 24a the resultant R of the two like forces P_1 and P_2 equals $(P_1 + P_2)$ and acts at a point B such that the distances a and b are inversely proportional to the forces P_1 and P_2, or

$$\frac{P_1}{P_2} = \frac{a}{b}$$

In Fig. 24b the resultant R of the two unlike forces P_1 and P_2 is equal to $(P_2 - P_1)$ and acts at the point A such that

$$\frac{P_1}{R} = \frac{a}{b}$$

MOMENT OF A FORCE

Concurrent forces acting on a body tend to produce motion in the direction of the resultant force. Such motion is spoken of as one of translation, since the motion is in a straight line. Another kind of motion is that of rotation in which case the given force tends to rotate the body about a fixed axis. Thus the tension in a belt causes the pulley, on which it is acting, to rotate about its fixed center. Hence:

The tendency of a force to produce rotation of a body about a definite or imaginary axis is called the moment of that force.

The *measure* of the *moment* of a force is the *product of the force times the perpendicular distance from the given axis to the line of action of the force.* Generally the distances will be expressed in feet, the forces in pounds and hence the moments will be given in foot-pounds.*

For convenience in the solution of problems, moments tending to produce rotation in the direction of the hands of a clock will be taken as positive (+) and all moments tending to produce counter-clockwise rotation as negative (—).†

COUPLES

Two equal and opposite parallel forces acting at different points of a body produce what is known as a *couple.* The perpendicular distance between the forces is called the *arm* of the couple. Since the forces are equal and opposite in direction the resultant force is zero and therefore the action of a couple is not to produce translation, but to produce, or tend to produce, rotation of a body. The moment of a couple is equal to the product of one of the forces times the perpendicular distance between the forces, or times the arm of the couple. No single force can balance a couple and hence the equilibriant of a couple is another couple equal and opposite to the given couple.

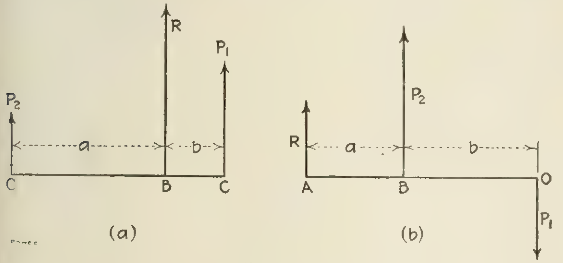


FIG. 24.

The moment of a couple remains constant, irrespective of the point about which the moments of the forces are taken. This may be proved as follows:

In Fig. 25, let the equal and opposite forces P_1 and P_2 produce a couple whose moment arm is CB. The moment of this couple about the point O equals

$$\begin{aligned} & P_1 \times OB + P_2 \times OC \\ &= P_1 (OB + OC) \text{ (since } P_1 = P_2) \\ &= P_1 \times CB \end{aligned}$$

Now assume some other point S. The moment of the couple about this point

$$\begin{aligned} &= P_1 \times SB - P_2 \times SC \\ &= P_1 (SB - SC) \text{ (since } P_1 = P_2) \\ &= P_1 \times CB \text{ (for } SB - SC = CB) \end{aligned}$$

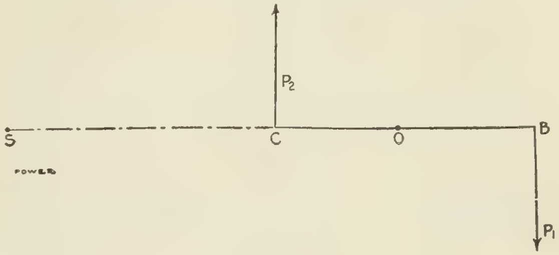


FIG. 25.

Therefore, the effect of a couple upon a rigid body is unaltered if it be transferred to any plane parallel to its own, the arm remaining parallel to its original position.

STUDY QUESTIONS

26. Two men carry a weight suspended from a horizontal pole. The one man exerts a pressure of 40 lb. and the other 60 lb. If the distance between the men is 10 ft., what is the magnitude and location of the weight? Neglect the weight of the pole.

27. A man turns the crank of a windlass. Is there a couple produced? If so, where is the second force?

28. The handle of a grindstone is 12 in. long. A man exerts a pressure of 30 lb. in the direction of motion of the handle. What is the turning moment produced?

29. A prony brake is clamped to the pulley of a motor. What is the turning moment or torque of the motor when a given armature current produces a net pull of 10 lb. at the end of the brake arm? The length of the brake arm is 24 in.

30. In question 9, Lesson II, determine the effective moment tending to rotate the crankshaft. Does this moment remain constant during a complete revolution of the engine? Assume the engine stroke to be 18 in.

⁂

High-School Boys in the Shops—Real industrial training that prepares for real jobs is described in a bulletin on the coöperative plan at Fitchburg, Mass., issued by the United States Bureau of Education. Boys in the Fitchburg high school, who attend alternate weeks in school and shop, are made to feel that their vocational training is serious business.

⁂

De Laval Pump for University of Illinois—The hydraulics laboratory of the University of Illinois has added another piece of apparatus to its equipment, there being installed a 4-in. three-stage De Laval centrifugal pump. It will be driven by a 50-hp. Westinghouse, variable-speed induction motor and will be capable of giving a discharge of 275 gal. per minute against a head of 400 ft. The pump will be so arranged that water can be drawn from the laboratory standpipe into the pump, and in this manner the total available head of 450 ft. can be had.

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*Many writers on mechanics prefer to use the term pound-feet for moments, to distinguish from the unit of work which is the foot-pound.

†Here again writers are not uniform, as some prefer to use clock-wise rotation as negative. In all problems in this course clock-wise rotation will be taken as positive.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Prof. Kent recently told the Sibley College students that the qualifications necessary for the position of general manager are "health, education, special knowledge, tact, energy, industry, personality, initiative, aggressiveness, and a degree of laziness." Omitting the last ingredient, this may be the reason for the scarcity of twenty-five thousand-dollar-men.

⁂

"A kiss is an operation performed on another's body requiring under all circumstances the recipient's sanction."—German supreme court decision.

Some fifty people have suggested this item as a "spill," 25 of whom are men, and for whom there is nothing doing! But in these days of feminism we are in doubt how the [illegible] others are going to act. Anyhow, we claim the right of appeal, your honor, and the line forms on the right.

⁂

The Canadian Pacific R.R. has added a "scout" to its staff. His duty is to "travel over the road and discover those employees who are especially worthy of advancement." Hail to the scout! Bet a railroad spike he'll be kept busy squaring himself with those who are worthy—and who get sidetracked from the Advancement division.

⁂

Contemporary announces that Frank Gilbreth has started a "Fatigue Museum." This listens like the name for a tramp's "hotel." It really is a museum showing devices that affect the well-being of the workman.

⁂

"Safety First" is printed on the pay envelopes of the employees of a lighting company. Some of these boys must have opened theirs before reaching home and dallied by the wayside. The advice is: "Don't go into dangerous places. Don't attempt to make adjustments. Don't disregard warning signs. Warn a man when danger is near. In case of doubt, adopt a safe course." All this preachment would be useless in a "dry" town.

⁂

Brother Rockefeller, among his many practical philanthropies, has established a million-dollar fund for research work of benefit to us humans. The government is helping the hogs and the sheep, so Brother John thinks he might as well be the goat and do something more for us lambs.

⁂

Reckon there's right smart white folks in the Anderson (S. C.) Cotton Mills. The other evening, a tol'able time after sundown, they-all had an ornery little fire "in the engine of the mill," says the local paper (though Brother Wright asseverates 'twas really the roof of the boiler house). But lordy, honey! time the Marthy Washington Hose No. 68 gets projectin' round the mill, the home talent and the comical sprinklers done squalshed the fire so doggone quick the Marthy Washingtons didn't even get to pumpin'—and they're some critters at a fire.

⁂

Brooklyn's Polytechnic Institute has a Mermaid Club—and has had for 10 years. The original club of this name was started in London by our old friend Walt Raleigh, and was frequented by Ben Jonson, Beaumont and Fletcher, and perhaps Mad Will. Our "Webster" further says a mermaid's a siren, and a—something worse. Probably Noah (meaning Webster) had in mind some of the original members when he made that third definition. These "Poly" boys (both the old and the young) are just regular chaps, and good fellows.

⁂

What a pity it is that religious bias and race prejudice so largely influence us. Nowhere on God's green earth are there such golden opportunities to practice the "live-and-let-live" idea than in these United States! Our country is the haven of the oppressed, the school of the unlearned—the one big chance to get ahead on our own initiative, and be something! At one time or another, we were all "foreigners," weren't we?

And because many of us can't agree as to how a man shall do his praying, if any, and because we can't see how the Almighty committed the mistake of creating any other race than our own, we go on sneering, and despising, and exhibiting our narrow souls and our mean prejudices. Say, let's buck up, and see if we can find SOME good in them all. Let's cultivate the true American spirit and be big, and more broad, and more kindly!

Influence of Volatile Matter on Combustion*

BY SAMUEL B. FLAGG

In handling the combustion problem, the difficulty of obtaining an intimate mixture of air and combustible gases before they come in contact with surfaces which lower the temperature below the ignition point, is the greatest to be overcome. As to the proper furnace construction to bring about this mixture, we are today in need of information.

Investigations by H. C. Porter and F. K. Ovitz‡ and by others show decided differences in the quantities of smoke-producing volatile matter distilled or driven off from different coals, or even from the same coal under different conditions of heating. Curves showing the quantities determined for several coals are shown in Fig. 1.

To illustrate, if it is assumed that Pocahontas, Connellsville, Zeigler (Illinois) and Dietz (Wyoming) coals can be burned with the same overall efficiency, the quantities of these coals required to evaporate a given quantity of water will be as 1: 1.05, 1.23: 1.39. If the temperature of the furnace in which these coals are burned is about 1650 deg. F., the quantities of smoke-producing volatile matter driven off will be as 1: 93, 1.55: 1.86. The furnace and the method of operation must, therefore, be adapted to take care of nearly twice the quantity of smoke-producing gases and vapors if Connellsville coal is to be used instead of Pocahontas.

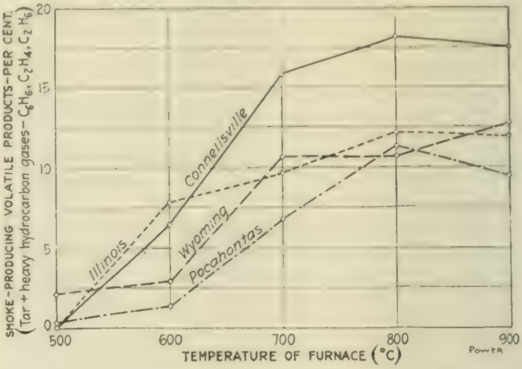

FIG. 1. QUANTITIES OF SMOKE-PRODUCING VOLATILE DISTILLED FROM SEVERAL COALS

The problem is further complicated in that the volatile matter of the Connellsville coal is of a different character than that of Pocahontas and requires more air for its combustion. For instance, the experiments show that the quantity of tarry matter, which is most difficult to break down and completely burn, from the Connellsville coal would be almost double that from Pocahontas. If the Zeigler (Illinois) and Connellsville coals tested by these men be compared in a similar way, it will be found that, although the amount of Illinois coal required to evaporate a certain number of pounds of water will be more, the quantity of smoke-producing volatile matter from it will be only 80 per cent., and the quantity of tarry matter only 95 per cent. of that from the Connellsville coal. From these few figures it is evident that the character of the coal increases or decreases the difficulty of obtaining complete combustion.

In plants which are mechanically stoked, the lessening or the prevention of smoke emission is accomplished largely through the decrease of the rate of heating of the coal or through the better mixing facilities, or both.

In some respects the problem of obtaining complete and at the same time efficient combustion is much more difficult in the case of hand-fired furnaces than where the stoking is mechanically done. In spite of this, however, the design of mechanically fired furnaces has been given the greater amount of real scientific study.

Some four years ago the Bureau of Mines, realizing the need of more complete information concerning the effect upon efficiency and smoke emission of differences in methods of firing, and of certain features of design of hand-fired furnaces, planned a series of tests which have since been carried out. A report of the tests and the results obtained is now in press.

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*A paper read before the Cleveland Engineering Society.

†Engineer of the United States Bureau of Mines.

‡"The Volatile Matter of Coal," H. C. Porter and F. K. Ovitz, Bureau of Mines Bulletin 1, 1910, pp. 32 and 34; also "The Smokeless Combustion of Coal in Boiler Furnaces," D. T. Randall and H. W. Weeks, Bureau of Mines Bulletin 40, 1912, pp. 173 and 174.

Figs 2, 3 and 4 show the several arrangements of the setting with which tests were conducted, and Table 1 gives the principal results. With each arrangement of setting, trials were made to ascertain the effect of the method of firing, and with some of them to observe the effect of supplementary air admitted into the furnace or combustion chamber. The rate of combustion was practically the same—approximately 15 lb. per square foot of grate per hour—for all tests, and the coal, although it was not all produced at one time, was all slack coal from the Pittsburgh seam and of the same general character throughout. A general discussion concerning the effect of the several features of these furnaces and of the method of firing is given in the report mentioned, and it will soon be ready for distribution. At different times in these experiments, each of the three following methods of lessening smoke were employed: Extra air, better mixing facilities, and decreasing the rate of heating. The effects of each in decreasing smoke are evident.

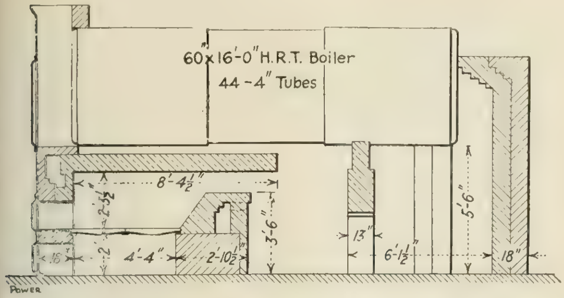

Fig. 2. Setting with Brick Arch over Grate

To determine just what changes are taking place in a furnace is always a difficult, if not impossible, task. On account of the observed difference in smoke emission under the different firing conditions, however, an effort was made to analyze the combustion process insofar as the rate of distillation of the volatile matter was affected by the method of firing.*

In the tests conducted with the several arrangements of setting, it was observed, whenever the firing was done by the alternate spreading method, that, although the total period of smoke emission was about the same, the duration of the dense smoke emission was greater than when the coking method of firing was employed. The furnace temperature was also higher when firing alternately. In starting to make the analysis it was assumed that, for any one coal, each arrangement of the furnace imposed a certain limit to its capacity to burn volatile matter; that is, when the rate of distillation reached a certain figure some of the volatile combustible would begin to escape unburned and appear as smoke, even though the supplementary air-admission openings were used. Conversely, when the rate of distillation from a newly charged lot of coal decreased to this critical figure, smoke would cease to appear at the top of the stack.

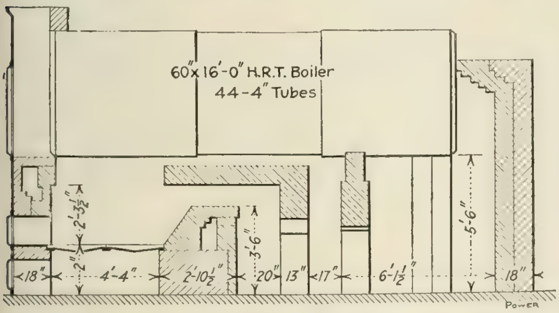

Fig. 4. Setting with Deflection Arch and Shell above Grate Exposed

In drawing the hypothetical curve of distillation of volatile matter for the spreading and for the coking method of firing, Fig. 5, it was, therefore, assumed that points on both curves represent the critical rate and have ordinates of the same height, and each has an abscissa representing a time interval of two minutes after the firing starts, since ordinarily no smoke was observed with either method of firing two minutes after the firing. The point at the end of the five-minute period (upper curve) was arbitrarily assumed to represent the rate at which the volatile matter was being evolved at the end of the period, and the general form of the curve for the spreading method was taken to be somewhat similar to that shown. The curve representing the conditions in the furnace as a whole, however, is made up of curves representing the distillation on the two sides of the grate, which latter are five minutes behind one another, since this was the firing interval when the alternate spreading method was employed. The form of the resultant curve was, therefore, adjusted to correspond with curves for each half of the grate drawn to represent as nearly as possible the conditions observed during the tests.

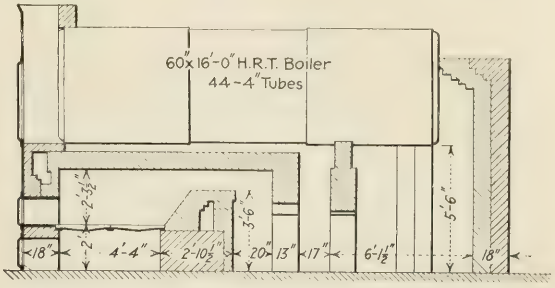

Fig. 3. Setting with Furnace and Deflection Arches

The other resultant curve (lower curve, Fig. 5), representing the coking method of firing, was prepared in a simliar

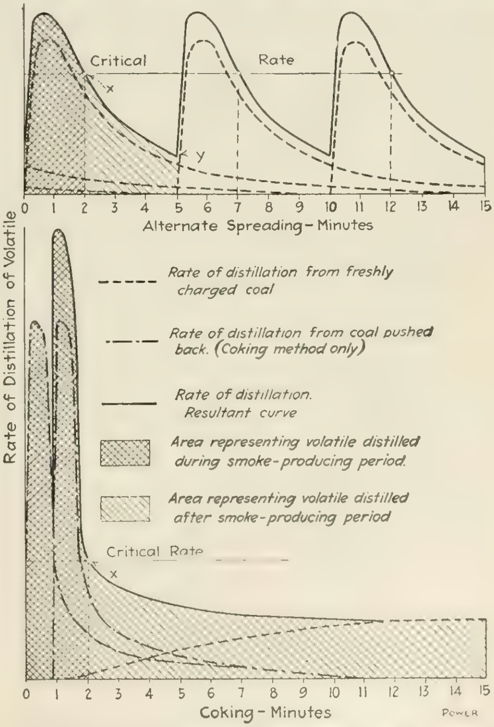

Fig. 5. Showing Rates of Distillation of Volatile for Alternate and Coking Firing

way. Whenever this firing method was employed observations showed that the most rapid distillation of volatile matter occurred immediately after the partially coked coal on the front of the grates was broken up and pushed back. At this time the evolution was at a high rate, but maintained for a short time only. The newly charged coal, of course, began to distill its gassy constituents as soon as it was placed in the furnace, but at a slowly increasing rate which became almost constant during the latter part of the 15-minute firing period.

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*For assistance in making this analysis, acknowledgment is due C. C. Cook, of the Bureau.

Under the conditions as indicated by these curves the smoke producing period would be six minutes out of 15 when the firing was done by the alternate spreading method, and two minutes out of 15 when the coking method of firing was employed. The height of the rate of distillation curve during the smoke producing period in the latter case might seem to indicate that the most dense smoke would be emitted under the coking method of firing. As a matter of fact, ordinarily the most dense smoke was made when the other method was employed, and the explanation probably is that the firing doors, which must necessarily be open for a longer time to fire by the coking method, admit large quantities of air during the time that the most rapid distillation takes place.

While these curves are based on assumption, the truth of which has not been demonstrated, the correspondence with observed conditions would seem to justify the conclusion that they are approximately representative. One point of particular significance is that from the coal fired in any 15-minute period, 61 per cent. of the volatile matter is distilled at a rate above the critical if the firing is by the alternate spreading method, whereas only 41 per cent. is distilled if the other method is employed.

The author's idea in attempting this analysis was that it might make more clear the nature of the problem to be dealt with in hand-fired furnaces, and we may, therefore, stop to consider what the study has revealed. The wide variation in the rate of distillation under either condition of firing, which is shown by the curves, certainly emphasizes the importance of adequate mixing facilities. In the tests mentioned the gas analyses show, in most cases, 60 to 75 per cent. excess air with no CO or other combustibles, but the inability to obtain smokeless combustion proves the inadequacy of the brick arches and piers to properly mix the air and volatile combustible matter at the time of most rapid distillation. The admission of supplementary air through openings at the front of the furnace immediately after times of firing made a marked difference in the smoke emission and demonstrated the effectiveness of the expedient. Some idea of the difference may be gained from Figs. 6 and 7.

The smoky condition prevailed immediately after a firing had been made, without using the air opening at the front; the other view, taken about the same length of time after another firing of approximately the same quantity of coal, was made in a similar way, except that supplementary air was admitted. It should not be inferred, however, that it was possible to prevent smoke emission at all times by this means.

The importance of controlling the rate of distillation and of keeping it as nearly uniform as possible, is also illustrated by the curves. In one case, the volatile matter is being distilled at a rate above the critical for only two minutes out of 15, or about 13 per cent. of the time; in the other case, the distillation at the excessive rate covers a period approximately three times as long. If the same quantity of volatile matter represented by the curves were driven off at a uniform rate, the critical rate for that furnace would not have been exceeded and the combustion would have been smokeless. To obtain this uniformity of rate of distillation in hand-fired furnaces, however, is impossible, although the variations by proper construction and operation of the furnaces may be reduced.

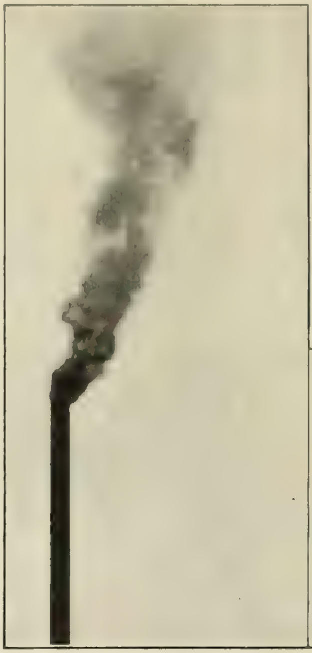


FIG. 6. JUST AFTER FIRING; NO SUPPLEMENTARY AIR USED

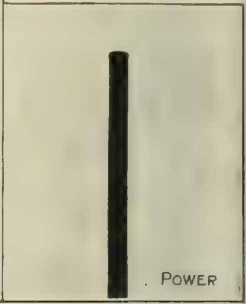


FIG. 7. AFTER FIRING; SUPPLEMENTARY AIR USED

PRINCIPAL RESULTS

	Series No.	Auxiliaries Used None Coking	 None Spreading	 Air Over Fire Coking	 Air Over Fire Spreading	 Air Through Bridge Wall Coking	 Air Through Bridge Wall Spreading	 Steam Jets Over Fire Coking	 Steam Jets Over Fire Spreading	 Steam Jets and Air Over Fire Coking	 Steam Jets and Air Over Fire Spreading
Efficiency of boiler and grate, per cent	1	55.9	60.0	59.7	62.6	56.0	61.4	57.7	56.4	60.4	58.9
	2	57.1	59.7	59.6	60.4	61.1	61.8	57.0	58.8	60.2	60.8
	3	62.1	60.9	62.6	63.4	62.3	64.5	62.0	61.7	66.1	64.6
	4			57.9	61.6					58.6	62.5
	5			65.7	67.0					68.0	65.5
	6			64.7	64.3					63.0	63.4
Average density of smoke % black....	1	4.1	20.0	3.0	15.8	4.0	20.8	7.0	33.6	11.0	27.3
	2	10.4	25.4	11.1	20.0	9.0	16.1	14.3	31.0	9.7	21.2
	3	15.7	23.9	10.8	14.6	7.8	15.8	13.0	28.2	8.0	21.4
	4			4.9	14.0					3.0	11.3
	5			9.8	12.6					4.8	16.5
	6			4.2	20.4					3.8	13.6
Max. mins. of dens smoke, per hr.	1	2.5	14.5	2.0	13.5	2.0	14.5	6.2	30.0	7.5	23.0
	2	10.0	16.5	8.5	18.0	7.0	14.0	10.5	23.5	6.5	16.5
	3	13.5	18.6	7.0	11.0	4.5	8.0	9.0	23.5	6.5	18.0
	4			6.0	17.5					4.0	14.5
	5			6.0	7.0					3.0	11.0
	6			3.5	16.5					3.0	15.0
Flue temp. deg. F....................	1	601	534	575	536	576	541	561	545	549	556
	2	630	550	581	539	576	555	577	542	587	534
	3	566	561	526	537	549	529	542	526	534	500
	4			588	503					587	563
	5			574	559					526	547
	6			537	563					560	559
Carbon dioxide.....................	1	8.4	11.5	8.0	11.5	8.2	12.3	8.9	12.3	10.0	12.3
	2	9.2	10.7	9.6	10.8	9.3	11.4	8.5	12.6	9.4	11.6
	3	10.8	11.9	11.0	11.1	9.8	12.1	11.0	12.8	10.7	14.0
	4			8.9	10.4					8.4	10.5
	5			10.8	10.4					11.4	11.1
	6			11.6	12.6					10.3	11.6
Draft at breaching.	1	0.33	0.20	0.33	0.18	0.39	0.15	0.27	0.17	0.20	0.14
	2	0.30	0.17	0.23	0.18	0.22	0.16	0.24	0.12	0.22	0.13
	3	0.19	0.19	0.18	0.18	0.25	0.17	0.21	0.12	0.17	0.12
	4			0.23	0.18					0.24	0.18
	5			0.16	0.13					0.13	0.12
	6			0.34	0.30					0.41	0.34
Quality of refuse per cent. clinker.....	1	49	70	52	67	49	72	58	64	39	66
	2	52	58	53	66	55	62	62	70	63	69
	3	63	63	46	58	58	61	56	59	54	64
	4			41	43					32	39
	5			38	50					45	49
	6			35	52					27	55

In any furnace which is to be fired by the spreading method, frequency of firing tends somewhat to reduce the variations in rate of distillation, but the charging of green coal into a hot furnace in a comparatively thin layer on top of hot coals must inevitably result in a rapid distillation of the volatile products. It is, therefore, to be expected that the mixing facilities and the supplementary air must play the principal part in preventing smoke emission if that method is to be used. This statement should not be construed to mean that the rate of distillation will not be affected by the construction of the furnace; in fact, proof that it is so affected was furnished when the change was made from the setting shown in Fig. 3 to that in Fig. 4. The lowering of the furnace temperature, which was accomplished by the removal of part of the arch, made a marked difference in rapidity of distillation and in smoke emission. The effectiveness of structures to mix the gases seems to depend largely upon the sudden changing of the direction of flow of the gases and not upon breaking them up into streams of small cross-section.

The curves under discussion also illustrate the effect of a difference in method of operation upon the rate of distillation in this furnace. From them it is seen that by the use of one method it was possible to keep the distillation below the critical rate most of the time. Further improvement means the changing of the form of the curves so that some of the volatile products now distilled at an excessive rate may be driven off more slowly. The exposure of any water-cooled surfaces to the radiant heat from the fuel beds tends to keep down the temperature of the furnace and of the fuel bed, and hence it lowers the rate of distillation.

An increase in the frequency of firing by the spreading method will decrease the duration of smoke emission after each charging of coal and may decrease somewhat the area above the critical rate line and below the rate of distillation curve, but the variation in rate must still be large under these firing conditions. Inspection of the curve for the other method of firing shows that it is when the partially coked coal is pushed back that the excessive distillation occurs, but if the freshly charged coal could be more rapidly and more thoroughly heated, the curve representing the rate of distillation of this part of the volatile matter would be raised. In this way the proportion of the volatile products distilled at a rate below the critical rate would be increased and the variation in rate of distillation decreased. It is quite possible that a change in the construction of the brickwork at the front end of the furnace, so as to reflect more of the heat from the rear part of the fuel bed onto the green coal in the front, would make possible the accomplishment of the object.

In an earlier part of this paper mention was made of the application of the principles or methods of smoke prevention in mechanically stoked furnaces. Some of the problems of this character are perplexing, but ordinarily these troublesome phases are not encountered unless the installation is made under severe or limiting conditions such as are met in plants operating under heavy loads or those where it has been considered impracticable to set the stokers with the required combustion space. In some of the central stations in the larger cities where, for economic reasons, it is imperative that equipment be operated at maximum capacity during the hours of peak loads, the problem of preventing smoke is particularly difficult. Installations that could easily be operated without smoke under ordinary conditions may, under these circumstances, smoke seriously. It is quite possible that such plants may find it necessary to attack the smoke problem somewhere other than in the furnace, as some have already done.

The analysis of the combustion processes under the test conditions described is based largely upon assumption.

⁂

Power in the United Kingdom—At a recent meeting of the Manchester (England) Association of Engineers, Edward G. Hillier stated that the total horsepower in use in the United Kingdom was 10,578,475, nine-tenths of which was provided by steam engines. Steam turbines rated second in the list, gas engines third, and water power fourth.

⁂

Electric Power for Farmers—Having contracted with the River Falls Power Co., New Richmond, Wis., for a supply of electricity to be delivered at substations 20 miles apart along its interurban line, the St. Paul Southern Electric Ry. Co. announces that it will furnish current to light villages along the road, which is now under construction, and supply nearby farmers with electricity for light and power. The power company's contract contemplates the construction of hydroelectric plant improvements which will include a reinforced concrete dam 92 feet long across the Kinnickinnic River above Clifton, Wis.

Alaskan Water Power Urged

W. P. Lass, in an address on Mar. 16, in New York City, before the American Electrochemical Society declared that a proper development of the water power in southeastern Alaska would be more valuable than either the gold mines or fisheries.

The greater part of southeastern Alaska, Mr. Lass contended, although undeveloped, unsurveyed and unprotected, has been held in national forest reserves and little attention has been paid by anyone to its development and utilization. The present generation should use efficiently the great water supply of Alaska for power. It is an ever flowing source of power that lost today can never be regained.

⁂

Big Southern Power Organization

A $2,000,000 corporation to provide electric power and lighting facilities for the Santa Ynez valley, the northern end of the county and all of San Luis Obispo county, has filed articles of incorporation at Santa Barbara, Calif., being the Midlands Counties Public Service Corporation.

The present place of business is in Los Angeles. The stock is equally divided between common and preferred and the controlling interest has been secured by the incorporators subscribing $1,000,500.

The company has acquired the power plants at Santa Maria, San Luis Obispo, Lompoc and other points, and plans for immediate extensions are being made. The new company is a subsidiary of the San Joaquin Light & Power Co. A. G. Wishon, one of the incorporators in the Midlands concern, is general manager of the San Joaquin company.

Power will doubtless be supplied by the immense plants of the San Joaquin company in the Sierra Mountains.

⁂

Coming Meeting of the National District Heating Association

The sixth annual convention of the National District Heating Association will be held in Rochester, N. Y., May 26, 27 and 28, 1914. The program as arranged by the executive committee is substantially as follows:

Tuesday, May 26, 2:00 p.m.
Welcome Address.
Response.
President's Address.
Report of Secretary-Treasurer.
Appointment of Nominating Committee.
Report of the Underground Construction Committee.

Tuesday, May 26, 8:00 p.m.
Report of Nominating Committee.
Address—Speaker yet to be selected.
Address, "Manufacture of Welded Iron and Steel Pipe," accompanied by moving pictures.

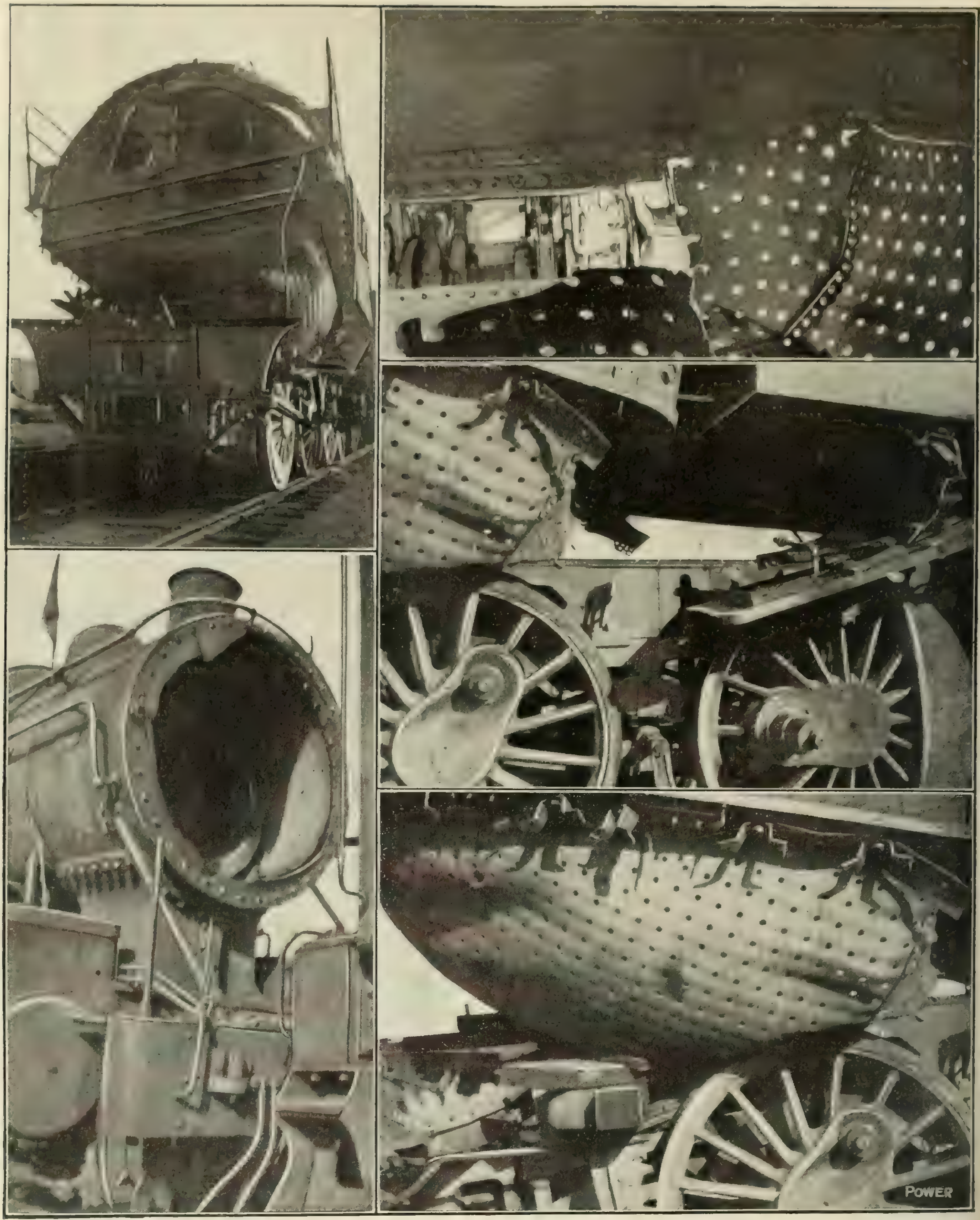
Wednesday, May 27, 9:30 a.m.
Report of Meter Committee, A. D. Spencer, Detroit, chairman. "Use of Bleeder Turbines in Connection with Steam Heating," R. D. DeWolf, Rochester, N. Y.
Election of Officers.
Report of Record Committee, A. P. Biggs, Detroit, chairman.

Wednesday, May 27, 2:00 p.m.
Discussion Session. The following subjects will be discussed:
"Hot Water Heating under Forced Circulation," Thos. Donahue, LaFayette, Ind., to open.
"Expense of Operating Centrifugal Pumps, vs. Double Acting Pumps," A. C. Rogers, Toledo, O., to open.
"Some Effects of Utility Regulation as Affecting District Heating," D. L Gaskill and H. Almert to open.
"Effects of Superheated Steam on Heating Systems," Davis S. Boyden, Boston, Mass., to open.
"District Heating for Small Towns and Cities of 10,000 Population and Under," L. T. Mason, Hornell, N. Y., to open.
"Heat Losses from Buildings of Latest Construction," H. Byers Holbrook, New York City, to open.
"Which is More Profitable, To Shut Steam Off at Night or Keep It on Continuously? "E. L. Wilder, Rochester, N. Y. to open.
"Economic Advantage to the Consumers of Central Station Heating Service Over Individual Heating Plants." N. M. Argabrite Elwood, Ind., to open.

Thursday, May 28, 9:30 a.m.
Report of Rate Committee.
"Customers' Steam Heating Systems," H. R. Wetherell, Peoria, Ill.

Thursday, May 28, 2:00 p.m.
"Commercial Steam Heating in New York City," Geo. W. Martin, general manager of the New York Service Co.
Report of Educational Committee, D. S. Boyden, Boston, chairman.
Report of Station Operating Committee, Byron T. Gifford, Grand Rapids, Mich., chairman.

There will be an exhibit in connection with the convention and elaborate entertainment will be provided.



Freaks of a Locomotive-Boiler Explosion

At 4:10 a.m., March 31, a freight locomotive on the Philadelphia & Reading Railroad, carrying 205-lb. pressure, exploded while climbing a heavy grade at Fanwood, N. J. (near Plainfield). The photographs reproduced tell the story in a graphic way. Fortunately no one was killed or seriously injured. The crown-sheet failure was due to low water. The rear and side sheets seem to have held, directing most of the force of the explosion forward.

Recent Court Decisions

Digested by A. L. H. STREET

Nuisance Produced by Sawdust as Fuel—A lumber company using sawdust as fuel in operating a steam power plant is held by the South Carolina Supreme Court to be liable in damages to an owner of nearby property for annoyance and discomfort caused him by partly burned sawdust, transformed into cinders and charcoal blowing upon his premises. (White vs. Halsey Lumber Co., 81 "Southeastern Reporter" 11.)

Establishment of Rates for Public Service—Under a very recent decision of the United States District Court for the district of Arizona, it is held in the case of Bonbright vs. Geary, 210 "Federal Reporter" 44, that a state commission, in fixing rates which may be charged by public service companies, must make the rates sufficiently high to yield a fair return on a reasonable valuation of the company's property employed in affording the service; and that the establishment of rates based upon undervaluation of such property, or upon an omission to value certain property so employed, amounts to an unconstitutional confiscation of property without adequate compensation.

Damages Recoverable for Smoke Nuisance—When a property owner establishes the fact that dense smoke discharged from a manufacturing plant settles on his property to the discomfort of the occupants, he is entitled to recover at least nominal damages, without further proof of injury, according to the decision of the Appellate Division of the New York Supreme Court in the recent case of Gibbons vs. N. Y. C. & H. R. R.R. Co., 146 "New York Supplement" 288. And when he shows that the rental value of his property has been depreciated on account of the nuisance, he is entitled to recover substantial damages, the court holds.

Power Plants as Part of Real Estate—The right of one who installs a power plant in a light manufacturing establishment to enforce a mechanic's lien to secure payment of the contract price was the subject of controversy in the recent case of Northwestern Lumber & Wrecking Co. vs. Parker (145 "Northern Reporter" 964) which was before the Minnesota Supreme Court. In holding that the plant in this instance was subject to lien as a permanent improvement of the land, as distinguished from a removable fixture, the court announced these principles: As between a seller and purchaser, or mortgagor and mortgagee of land, personal property which has been permanently affixed to the real estate becomes a part of the land. But, as between a landlord and tenant, fixtures installed by the latter may be removed during the tenancy, if the removal can be effected without injury to the premises. The right to a mechanic's lien in this case was not defeated by the fact that the tenant, with the landlord's consent but without knowledge of the lien claimant, executed a chattel mortgage to a fourth party, covering the power plant. The court's finding that the power plant became a part of the realty was influenced by the fact that the boiler and smokestack were firmly set in foundations forming part of the building, and that the engine was bolted firmly to the floor.

NEW PUBLICATIONS

ELECTRIC LIGHT AND MOTOR WIRING. By George J. Kirchgasser. Published by the Electroforce Publishing Co., Milwaukee, Wis., 1914. Size 3x5½ inches, 270 pages, illustrated. Price, $1.

A handy little book of vest-pocket size explaining the usual wiring methods such as open wiring, molding, concealed knob and tube, conduit, flexible conduit and armored conductors. These are well illustrated and a variety of electrical fittings is shown.

The first half of the book is devoted to lighting circuits and the second half to motor circuits. Such tables as would ordinarily be required by the electrician or architect are included, and typical wiring problems are worked out. Also, the latest restrictions and requirements of the National Electric Code as applied to wiring systems are considered.

APPLICATION OF POWER TO ROAD TRANSPORT. By H. E. Wimperis. Published by D. Van Nostrand Co., New York. Size 5x7; 130 pages, illustrated. Price, $1.50 net.

The material is drawn largely from a series of lectures delivered by the author before the Finsbury Technical College last year. In contrast to most books on automobiles, there is an absence of descriptive matter, the text following closely that phase of the subject prescribed by the title. Among the items taken up are: Resistance to motion in relation to loads, speeds and wheel diameters; amount of power necessary; loss of power in engine friction and in transmission gear; relation between engine dimensions and gear ratios to the work to be done; and significant points on automobile design. These subjects are treated clearly, and only simple mathematics are employed.

The appendix contains tables and the results of tests showing the relation between size of engine, maker's rating, brake horsepower and R. A. C. rating (which corresponds to our A. L. A. M. rating.)

Although based mostly on English practice, a large part of the text is fundamental and applies equally to American practice. The field for the book is exclusively that of the automobile engineer and designer.

ENGINEERING AFFAIRS

The April meeting of the Isolated Power Plant Association will be held in the Engineering Societies Building, 29 West 39th St., on Monday evening, Apr. 28, at 8:15. The question of extending the New York organization throughout the country will be taken up. Inquiries have come to this association from time to time in regard to the objects of the organization, and it is to be seen from the tenor of the inquiries that other localities are in pressing need of information. The status of the Edison rate case will receive attention at the meeting and also a number of new cases affecting electric rates in New York. Some of them have developed points of considerable importance as bearing upon the general question of rates.

The second annual banquet of the Bliss Electrical School Alumni Association was held April 13, President Louis D. Bliss, of the Bliss Electrical School, Washington, D. C., presided. Among the speakers were H. C. Fleming, of the Pennsylvania Public Service Company, Indiana, Penn.; John W. Ward, general superintendent the Pittsburgh High Voltage Insulator Co., Derry, Penn.; E. M. Kreidler, the Union Switch & Signal Co.; Alexander Weinberg, president Duplex Electric Manufacturing company; James S. Dodds, instructor Carnegie Institute of Technology; E. J. Dovey and G. R. Jennings, Duquesne Light Co.; N. P. Knowles, Central District Telephone Co.; C. A. Batton, J. B. Harris Jr., S. B. Hull, M. B. King, C. A. Purdy, H. E. Renkert, C. E. Smith and C. P. Walker, of the Westinghouse companies.

The annual exhibition of the work of day students of Pratt Institute, Brooklyn, N. Y., will be held as follows: Thursday, Apr. 30, 2 p.m. to 10 p.m.; Friday, May 1, 10 a.m. to 10 p.m.; Saturday, May 2, 10 a.m. to 5 p.m. This exhibition is open to the public and a cordial invitation is extended to all who are interested in industrial and technical education. The students will be engaged at their regular work, and an opportunity will thus be afforded to visitors to inspect the methods, equipment and general facilities for conducting this kind of training, as well as the finished products of the students in the various courses. Pratt Institute is a pioneer in the field of industrial education and for many years has been developing courses of the kind for which there is so strong a demand at the present day. The school offers day and evening courses for both men and women in a great variety of vocational subjects, including fine and applied arts, household science and arts, architectural design and construction, library management, kindergarten training and technical and trade courses for men along many important lines. The work of the School of Science and Technology should prove of special interest to men engaged in technical and trade pursuits. It provides instruction in applied mechanics and machine design, applied electricity, applied chemistry and tanning, machine work and toolmaking, carpentry and building, pattern making, plumbing, foundry and forge work and sheet metal work.

PERSONALS

A. S. Baldwin has accepted the position as manager of works of the Best Manufacturing Co., Pittsburgh, Penn. Mr. Baldwin was formerly general manager of the Alberger Pump & Condenser Co., Newburgh, N. Y., which position he resigned on the first of April.

BUSINESS ITEMS

Owing to the continual growth of its business the Scandinavian Belting Co. will on or about May 1 remove its New York office to 106-108 Reade St.

The Shipley Construction & Supply Co., domestic and foreign agents for the York Manufacturing Co., are now occupying offices in its new building, corner of Columbia and Warren Sts., Brooklyn, N. Y.

The Dearborn Chemical Co. has transferred its southeastern branch office from Birmingham, Ala., to Atlanta, Ga., 1107 Candler Building, where C. H. Everett and J. F. Boutelle, representing the Dearborn company in that territory, will have their headquarters.

F. S. Palmer, the well known engine-stop man, is back with the Locke Regulator Co., of Salem, Mass., as manager of the engine-stop department. Mr. Palmer some years ago had been a representative for the Locke Regulator Co. and his friends will be glad to hear of his return to his old company.

Warren Webster & Co., Camden, N. J., has just published a very interesting booklet on the Webster Vacuum System of Steam Heating. It illustrates many of the largest buildings and hotels in different cities in which this system is installed and is full of valuable steam-heating data. The number of the booklet is B 87h and is mailed on request.

The Ingersoll-Rand Co. has opened a new branch office and warehouse at 1036 Union Oil Bldg., Los Angeles, Calif. W. A. Townsend, formerly manager of the El Paso office, will be in charge. J. D. Foster succeeds Mr. Townsend as manager of the El Paso branch. This company has also opened a branch in the city of Juneau, Alaska, with Frank Carroll in charge. Walter A. Johnston is now pneumatic-tool manager of the Pittsburgh branch, and C. F. Overly of the Cleveland branch.

Among recent sales of "Economy" turbines made by Kerr Turbine Co., Wellsville, N. Y., are the following: Thirteen units for driving pumps, Swift & Co.; six units for driving pumps, Crane Co.; three turbo pumps, Lackawanna Steel Co.; one turbo pump, American Sheet & Tin Plate Co.; 100-hp. unit, Carnegie Steel Co., 150-hp. belted unit, Bodcaw Lumber Co. Turbo-generators as follows: 500-kw. unit, Coy Paper Co., 250-kw. unit, Standard Oil Co. (2); 200-kw. unit, Taggart Bros. Paper Co.; 150-kw. unit, Glasgow Electric Light & Ice Co., city of Ravenna (Ohio), and Kerite Insulated Wire & Cable Co., 125-kw. unit, Ypsilanti Reed Furniture Co., 100-kw. unit, Gulf Fisheries Co.

G. L. Simonds & Co., 500 Gaff Building, Chicago, Ill., have recently secured contracts for installation of Vulcan soot cleaners from S. F. Bowser & Co., Fort Wayne, Ind.; North Western Penn. Ry. Co., Meadville, Penn.; Duquesne Lighting Co., Brunot's Island Power Plant; Pittsburgh, Penn., 20 cleaners; Mahoning & Shenango Ry. & Light Co., Lowellville, Ohio; Babcock & Wilcox Co., for Cincinnati Water works; Babcock & Wilcox, for Orrville Water works, Ohio; Penn Central Light & Power Co., Warrior Ridge, Penn. Also for Williamsburg, Penn., plant; Penn Public Service Co., Phillipsburg, Penn.; U. S. Aluminum Co., New Kensington, Penn.; Transue & Williams, Alliance, Ohio; Havana Electric Ry., Light & Power Co., Havana, Cuba; Merchants Heat & Light Co., Indianapolis, Ind.

The A. S. Cameron Steam Pump Works, 11 Broadway, N. Y., has opened branch offices and warehouse in the following cities: Birmingham, Ala., American Trust Bldg., H. M. Perry, mgr. Chicago, Ill., Peoples' Gas Bldg., M. P. Frutchey, mgr. Cleveland, Ohio, Williamson Bldg., W. A. Armstrong, mgr. Duluth, Minn., Providence Bldg., S. H. Hill, mgr. Houghton, Mich., Thos. F. Lynch, mgr. Knoxville, Tenn., Holston National Bank Bldg, L. F. Thompson, mgr. Los Angeles, Calif., W. A. Townsend, mgr. Philadelphia, Penn., Arcade Bldg., Phil. Weiss, mgr. Pittsburgh, Penn., Farmers' Bank Bldg., W. B. Brendlinger, mgr. St. Louis, Mo., 300 N. Broadway, A. A. Bonsack, mgr. Seattle, Wash., Colman Bldg., R. W. Douglas, mgr.

NEW EQUIPMENT

ATLANTIC COAST STATES

The plant of the Deposit Electric Co., Deposit, N. Y., was recently destroyed by fire. Estimated loss, $25,000.

SOUTHERN STATES

Plans are being prepared for the installation of an electric-light plant in Woodland, Ga.

The Nashville Cold Storage & Ice Co., Nashville, Tenn., will purchase four 800-hp. boilers for its plant.

CENTRAL STATES

The installation of a municipal electric-light plant at West Union, Ohio, is under consideration.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c an insertion, in advance.

Positions Open, (Civil Service Examinations), Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work) and For Sale, 5 cents a word, minimum charge, $1.00 an insertion.

Miscellaneous (Educational—Books) 10 cents a word, minimum charge $1.50.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion.

Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on or up to the dates given. For detailed information, write the United States Civil Service Commission, Washington, D. C., or other addresses specified.

JUNIOR ELECTRICAL ENGINEER (Male) $1080-$1500; examination May 20, for vacancy in the Interstate Commerce Commission, and positions that become vacant requiring similar qualifications. Write for Circular 397, Application Form 2039.

POSITIONS WANTED

GRADUATE MECHANICAL ENGINEER, several years' commercial experience on power apparatus, also testing and design; references. P. W. 206, Power.

MECHANICAL ENGINEER, graduate, 28, with practical experience on boiler-room work, ice plant, electric plant and water supply; hustler who can carry out responsibilities seeks permanent position. P. W. 207, Power.

ELECTRICIAN AND MECHANIC with broad experience, installation and operation of hydro-electric, gas and oil engine power plants, high tension transmission; age 30, married, speak Spanish; best of references. Lock Box 10, Shreve, Ohio.

WANTED

AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

SPECIALTY MEN in every city calling on power plants to sell our patented pump valves; liberal commissions. George C. Van Vechten Co., 255 Main St., East, Rochester, N. Y.

MISCELLANEOUS

PATENTS SECURED—C. L. Parker, Patents 904 G St., Washington, D. C.

ENGINEERS—Do you want to utilize your exhaust steam for heating or driving purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

FOR SALE

AUTOMATIC STEAM ENGINE—25 hp. Brownell, almost new; must move to make room for larger engine. Box 12, New London, Minn.

BOILER—350-hp. water tube, used 30 days; insured 200 lb. steam pressure; cost $3500; price, $1500. Duzets & Son, Hudson Terminal, New York.

FOUR-VALVE RUSSELL ENGINE, one, 14x20, left hand; diameter wheel, 88 in.; face, 18 in.; good condition. Municipal Electric Light Plant, Blessfield, Mich.

DYNAMOS—Two 75-kw. Westinghouse, 125-volt, direct connected Ames automatic engines; $975 each. Duzets & Son, Hudson Terminal, New York.

GENERATORS—Two 75-kw.-Wheeler, 250-volt, direct-connected Harris Fleming engine, with switchboards; $1200 each. Duzets & Son, Hudson Terminal, New York.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

WORTHINGTON PUMPS—Two 20x12x15, in working order (with or without fittings); capacity too small for present demands. One Stillwell open heater. Address John M. King, Superintendent of Lancaster Water-Works, Lancaster, Ohio.

1—1000 KW. FILER & STOWELL; 1—1200 kw. Rice Sargent; 1—600 kw. Allis-Chalmers. Vertical engines complete with generators and condensing plant, etc., and in good operating condition. Call or write for further particulars. Western Electric Co., Purchasing Dept., Hawthorne Station, Chicago, Ill.

NO. 21 STIRLING BOILERS—Three class A, 280 hp. each; one class A No. 24 Stirling Boiler, 320 hp., with Dorrance shaking grates, complete with fronts, drums, framework, no tubes; best condition, 160 lb. pressure, one year's use; stored ready for inspection or shipment. A. E. Staley Manufacturing Co., Decatur, Ill.

BUCKEYE STEAM ENGINES—Two at bargain prices. One 12"x21" 85 hp., 185 r.p.m., 85 lb. steam pressure; flywheel 6' 0" diam. 22" face. One 11"x18" 70 hp., 200 r.p.m., 85 lb. steam pressure; flywheel 4' 0" diam. 14" face; changed to motor drive. Must move at once. Write today. The W. H. Mullins Co., Dept. C, Salem, Ohio.

CORLISS ENGINES—1100 HP—26&42x48 Vilter Cross Compound Corliss Engine, Belt Wheel 18'. 800 HP.—22&32x42 Allis Corliss Tandem Compound, Right-hand, 18' Belt Wheel, both Engines perfect condition. Have to move immediately so make price; each engine $1050 f.o.b. cars, guaranteed excellent condition. Harold R. Wilson Machinery Co., 413 Pine St., St. Louis.

POWER

Vol. 39 NEW YORK, MAY 5, 1914 No. 18

The Life of the Engineer

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By Charles H. Bromi

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YOU say my life's intensely dull,
Monotonous—a stupid lull,
Without a goal to raise hopes high
And that if you were me you'd die?

Now what do you, with unsoiled hands—
Your smooth, clean face and linen bands—
Know of the joys, the frights, the peace,
Found in my world of steel and grease?

At cranky pumps, I've worked and cursed
As tons of sea through great holes burst
And strove to fill the darkened hold
So rapidly my blood ran cold!

In settings hot with glowing soot;
My hide's been scorched from head to foot.
I've put grates back when dropped from place,
While burning coals fell on my face.

Those days are gone and though they had
Their times that almost drove me mad,
What recollections still remain
Are more of pleasure than of pain.

I often think of friends of old,
Case-hardened men with hearts of gold,
Who'd share their last, and gladly too.
Would your pals do as much for you?

And now my task's to work and plan
To get the best that human can
From this big modern plant ashore;
A worthy goal I'm striving for.

Oh, no, young man, a thousand "no's!"
My life's not drear nor dull, God knows!
But yours! 'Tis likely tame, I fear,
Beside that of the engineer.

New Turbine Power Plant of the Louisville Railway Company--I

By W. O. Rogers

SYNOPSIS—A modern steam plant, built on the unit system, with an initial capacity of 12,000 kw. and an ultimate rating of 48,000 kw. The building is constructed to be gradually extended. The handling of fuel and ash and supplying circulating water to the condensers are also features. The circulating pumps are at the bottom of a pit, 35 ft. below maximum high water, and but 3 ft. above the low-water stage of the Ohio River.

⁂

The electrical energy for operating 165 miles of city and 96 miles of interurban track prior to the completion of the new High St. power plant, was supplied from the old Campbell St. plant, which had a total rated capacity of 11,600 kw. at 13,200 volts. The old plant was supplanted for several reasons, the two of most importance being the lack of circulating condenser water and the rapid increase in the electrical output.

Circulating water was obtained from Beargrass Creek, on which the plant is situated, and which received the discharge from a number of sewers; it maintained, however, a fairly constant water flow and did not prohibit the use of the water for condensing purposes. Within the past five years the city of Louisville has constructed sewers parallel to the creek, and so diverted the flow of water that sufficient circulating water was not available.

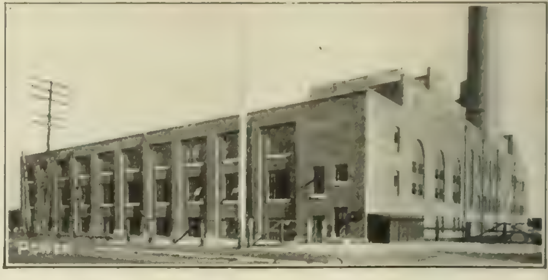


Fig. 1. High Street Power Station

Artesian wells were sunk and a spray cooling system was installed to furnish condensing water, but the water supply was limited and the idea was costly, because of the

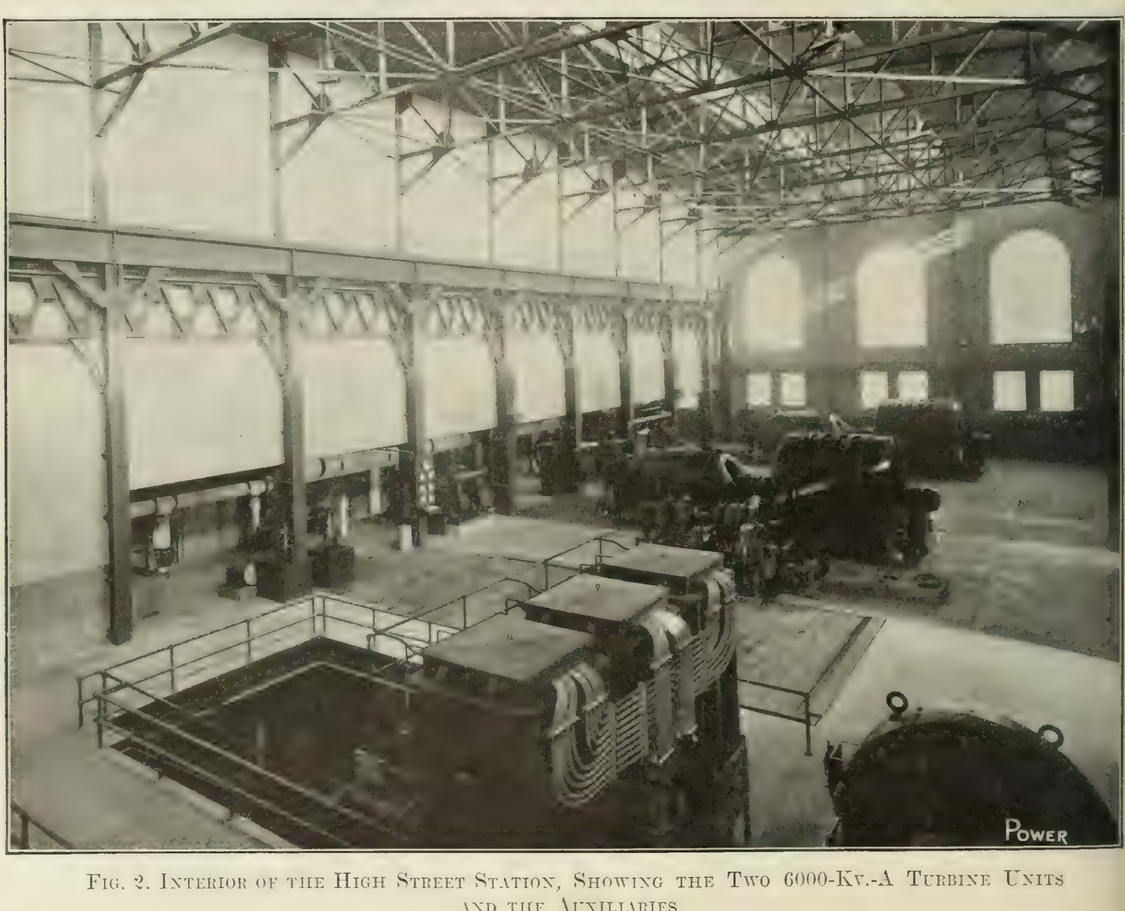


Fig. 2. Interior of the High Street Station, Showing the Two 6000-Kv.-A Turbine Units and the Auxiliaries

amount of pumping necessary; the efficiency was materially reduced, and extensions could not profitably be made to the old plant.

Another reason was that the average daily output in the old plant had increased from 35,000 kw.-hr. in 1900 to practically 150,000 at the close of 1912, and the maximum hourly load demand rose from 3000 kw. in 1900 to 14,000 in 1912. This rapid increase in output was due to increased car and track mileage, and to the size and equipment of the cars.

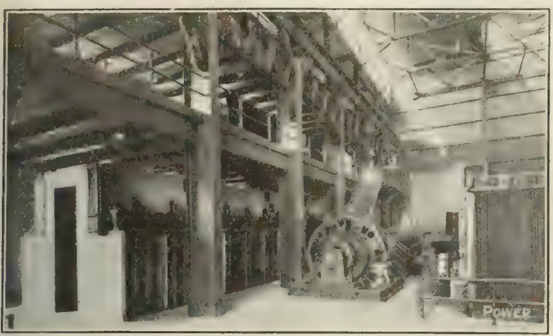


Fig. 3. Rotary Converter, Transformers and Oil Switches

The new station site is on the Ohio River, but separated from it by the Kentucky & Indiana Terminal R.R. and the Louisville & Portland Canal, the latter having been built as a means of transportation past the rapids during low-stage periods of the river. The power house is above the locks, where there will always be an abundance of water for power-plant consumption.

The new plant site fronts 1358 ft. on the railroad, a part of a double-track line about half-way around the city, and connects with all steam roads entering it. The general level of the property is about 5½ ft. above the maximum high-water stage of the river, and is underlaid with bed rock at a depth of about 36 ft.

Construction work was begun on May 1, 1912, and 19 months later, Nov. 23, 1913, current was first generated. The building, Fig. 1, is of steel, concrete and brick construction, but the west side is closed in with a temporary corrugated siding to be removed when future extensions are made. All foundations and walls up to the high-water line are built of concrete. The concrete foundations of the chimney, turbine and crane columns were built upon bed rock; all other supports rest upon concrete piles driven to bed rock. The roof of the building is made with a 2-in. course of reinforced concrete, a course of 6-in. hollow tile and a 2-in. finishing layer of concrete; the whole is covered with a layer of five-ply tar paper and gravel.

The building includes a 100x180-ft. boiler room built with the longer dimension at right angles to the turbine room, which is 80x175 ft. At the time of the writer's visit, there were two 6000-kv.-a. turbines of the semi-double-flow type, employing the impulse and reaction principles in operation. Steam at 180 lb. and 125 deg. superheat is used in the turbines. The generators are three-phase, 25-cycle, 13,200-volt machines with inclosed ends and forced ventilation. The cooling air is drawn through the cable room from outside the building and passes through copper-wire screens covered with cheese cloth, which catch the dust drawn in with the air.

Fig. 2 is a view of the turbine room looking east toward the permanent end. The condenser and pump pit is between the two main turbines. The electrical-controlling apparatus is on the near side of the room; the auxiliary units are shown on the opposite side under the boiler-room floor.

There are three auxiliary exciter units; 100- and 150-kw. engine-driven, 125-volt generators and one 50-kw. motor-generator set. There is also a 2000-kw., six-phase, 25-cycle, 13,200-volt rotary converter of the latest design. Provision has been made for starting it from either

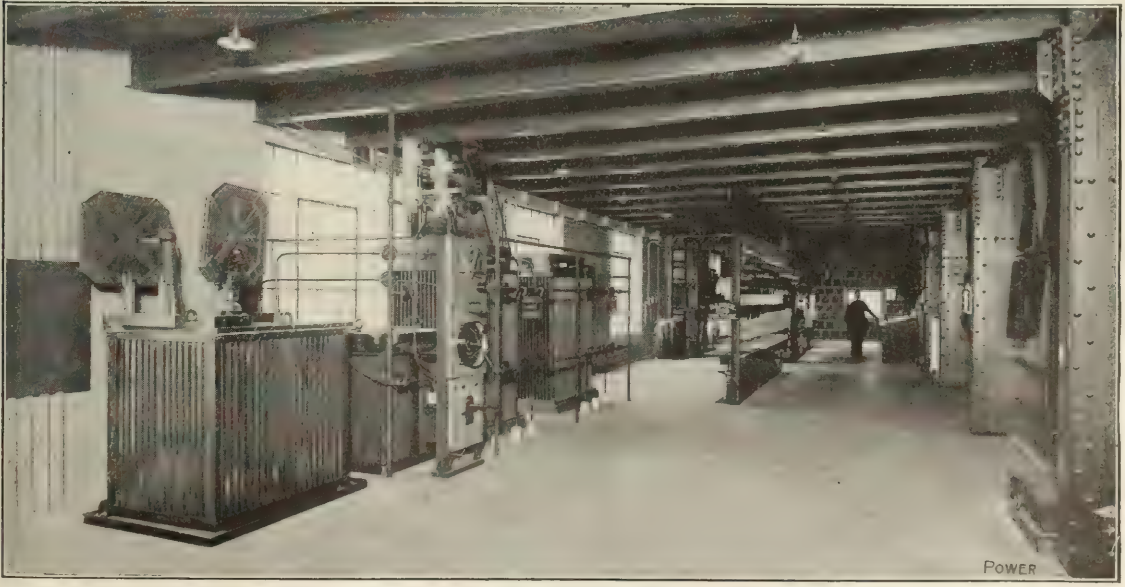


Fig. 4. View of the Switchboard Gallery, Looking West

the alternating- on the direct-current end. There are three 750-kw., single-phase oil-cooled transformers used for the rotary converter, stepping the current down from 13,200 to 380 volts. This equipment, which is tied in with two city substations by way of a 600-volt, direct-current trunk line, is shown in Fig. 3, also the concrete-incased oil switches and high-tension bus structure.

A four-level gallery flanks one side of the turbine room. On the lower one, which is below the turbine-room floor, are the underground transmission conduits. From the conduit the cable radiates through the necessary cable-end bells. The 13,200-volt busbars are in concrete compartments and automatic oil switches are installed over them, being shut in by full-length polished wire-glass doors. The switchboards are on the south side of the room on the second gallery. The desk-type control board, in two sections and designed for four generators, has a miniature busbar layout showing the connections of the generators and feeder, also the cross-connections of the bus system. A view of the switchboard floor is shown in Fig. 4.

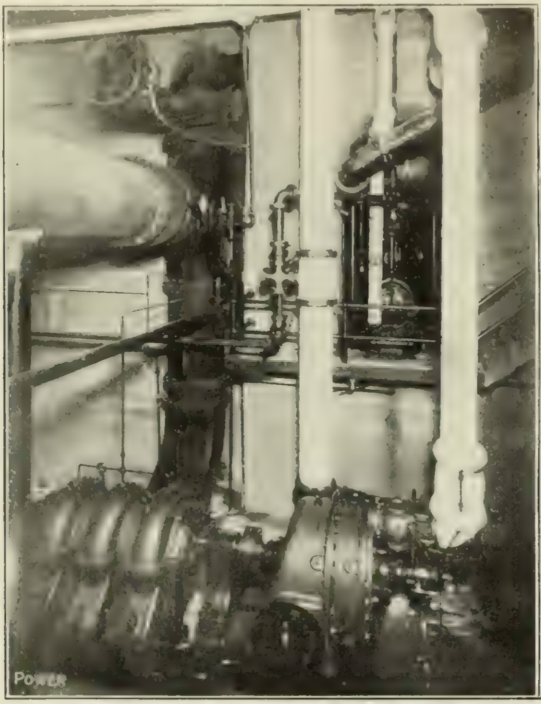


Fig. 5. Pump Pit, Showing Pumps and Concrete Turbine Foundation

Condensing Apparatus

A feature not found in the general design of power plant is in connection with the condensing apparatus. Each turbine foundation consists of two parallel walls and extends to within 18 in. of the main turbine floor, which is 12 ft. below the boiler-room floor, thus forming a bay where auxiliaries, pumps, etc., are placed.

The foundation walls are so spaced that the surface condenser may be lowered in place under each turbine by the overhead 50-ton crane. The turbines are on an I-beam grillage, supported by the two concrete foundation walls, the base of which is below the water level of the river, Fig. 5. In Fig. 6 is shown a part of one end of a condenser, one of the two 54-in. electrically operated valves and a 36-in. atmospheric exhaust valve and fittings. The piping is so arranged that the direction of the flow of water can be changed in the condenser by the manipulation of four valves; thus washing the refuse out of the condenser into the discharge tunnel, or any obstruction that might come in with the circulating water. These pumps, Fig. 5, driven by 280-hp., two-stage turbines, are in the condenser pit 35 ft. below the maximum high water and 3 ft. above the low-water stage of the river. The water for condensing purposes is taken from the canal, Fig. 7, and is conveyed to the pump pit through two 7×8-ft. concrete tunnels after passing through wire screens in the screen house.

The top of the eight canal intake openings is about 1 ft. below the normal water level, to eliminate, as much as possible, floating débris and to avoid frequent clogging of the screens. The openings for both the intake and the discharge are for a flow of 160,000 gal. per min. with a discharge current of 1.19 ft. per sec.; this is necessary so as not to interfere with small boats passing in the canal. This was accomplished by discharging from the bottom and from several outlets. The other end of the tunnels terminate under the circulating pumps in the pump pit.

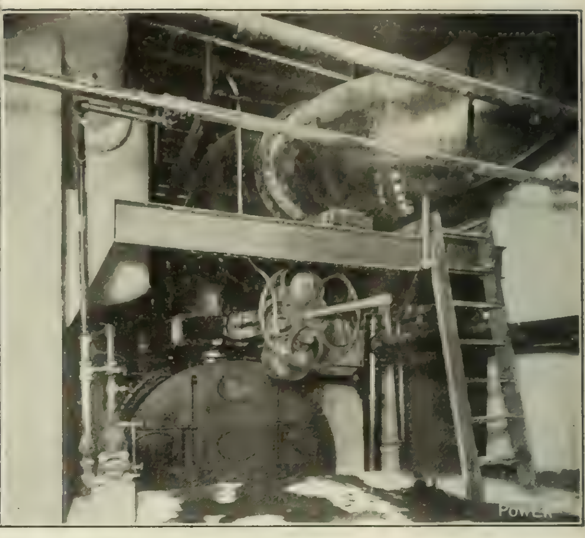


Fig. 6. End View of One of the Surface Condensers and Motor-Operated Valve

Two auxiliary 30-in. cast-iron discharge pipes extend from the east end of the discharge tunnel to a point on the canal over the intake. Should the canal water freeze, the discharged hot water can be used to melt any needle ice that may obstruct the tunnel entrance.

In the screen house there are four sets of double, brass-wire screens, two in series. The screens on the intake side have a ¾-in. mesh and those on the other a ½-in. mesh. The screens are mounted on metal frames and the whole can be raised to the floor of the screen room for cleaning, Fig. 8, by a five-ton electric traveling crane.

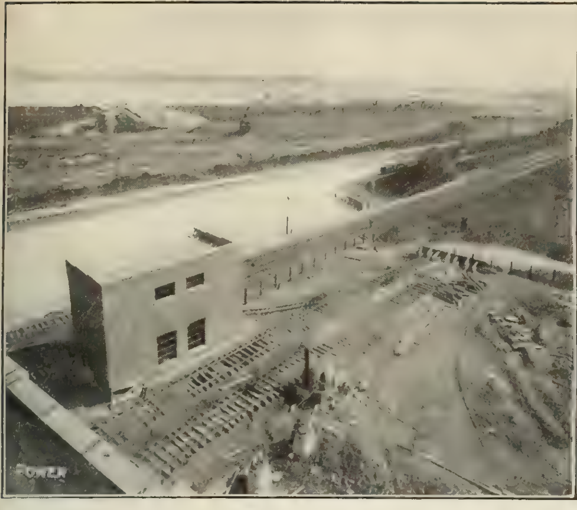


Fig. 7. Canal and Screen House, the Ohio River in the Distance

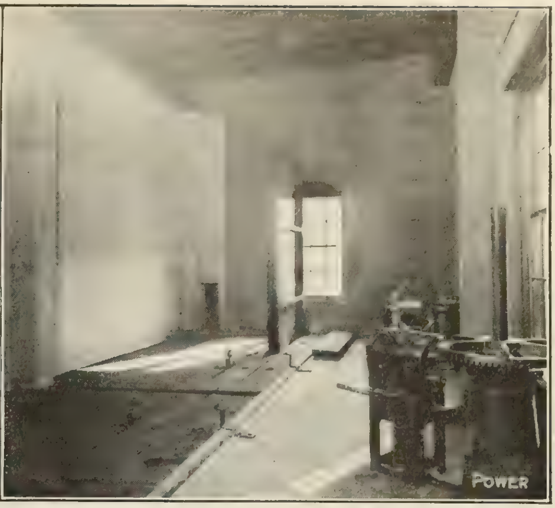


Fig. 8. Interior of the Screen House, Showing Screen Crane

Each tunnel can be shut off by sluice gates operated from the ground floor by means of worm gears. At the canal end of the tunnel a system of iron-bar racks, placed at 60 deg., and spaced 2½ in. apart, catches all heavy material and prevents damaging the smaller screens.

The concrete discharge tunnel from the condensers is horseshoe in shape, 9x9 ft., and empties into the canal 500 ft. west of the intake. Discharge pits have been built into the discharge tunnel below the flow line to seal the condenser discharge; the water-discharge entrance into the conduit is by means of flanged castings set in the concrete walls.

Condensate is taken from each hotwell by a 4-in. two-stage turbine pump driven by a small turbine. The pumps deliver water from the hotwell to the open heater in the boiler room at a maximum rate of 350 gal. per min. against a head of 60 ft. Makeup water is supplied from an overhead 35,000-gal. capacity steel tank by either of two 9, 14 and 8½ by 15-in. duplex compound pumps. The tank is above the elevator shafts of the boiler room and the water overflows at a height of 119 ft. above the turbine room. A float valve in the tank closes the inlet when the water rises to within 6 in. of the overflow. This action produces pressure on the pump discharge and the regulators automatically stop the pump. An elevation gage, installed over the engineer's desk, is graduated in feet to indicate the height of water in the tank. This water is not only used for makeup but for water-cooled glands in the main turbine, centrifugal pump and exciters.

PRINCIPAL EQUIPMENT OF THE NEW TURBINE PLANT OF THE LOUISVILLE RAILWAY CO

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Hor. semi double flow	6000 kv.a.	Main units	1500 r.p.m., 180 lb. steam, 125 deg. superheat	Westinghouse Mch. Co.
2	Generators	Alt. current	6000 kv.a.	Main units	1500 r.p.m., 13,200-volt, 3-phase, 25-cycles	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	150 kw	Exciter, turbine driven	2200 r.p.m., 125-volt, turbine driven	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	100 kw	Exciter, turbine driven	1800 r.p.m., 125-volt, turbine driven	Westinghouse Elec. & Mfg. Co.
1	Turbine	Horizontal, impulse	150 kw	Driving exciter generator	2200 r.p.m., 180 lb. steam, 125 deg. superheat	Westinghouse Mch. Co.
1	Turbine	Horizontal, impulse	100 kw	Driving exciter generator	1800 r.p.m., 180 lb. steam, 125 deg. superheat	Westinghouse Mch. Co.
1	Converter	Rotary	2000 kw	Trolley circuit	25-cycles, 6-phase, 13,200 volt interpole	Westinghouse Elec. & Mfg. Co.
3	Transformers	Single-phase	750 kw	For rotary transformer	Oil insulated, self cooled, 13,200 to 380 volts	Westinghouse Elec. & Mfg. Co.
2	Condensers	Surface	20,000 sq.ft. cooling sur.	Main turbines	29-in. vacuum	Henry R. Worthington
2	Pumps	Centrifugal tri-rotor	26-in	Circulating water	20,000 gal. capacity, turbine driven, 1000 r.p.m.	Henry R. Worthington
2	Turbines	Two stage	280 hp	Driving circ. pump	1000 r.p.m., 180-lb. steam	General Electric Co.
1	Crane	Traveling	5 ton	Hoisting screens	Electrically operated—600 volt, d.c.	Whiting Foundry Equipment Co.
1	Crane	Traveling	50 ton	Turbine room	3-motor operated—600 volt, d.c	Whiting Foundry Equipment Co.
2	Pumps	Turbine, two-stage	4-in.	Hot well	Turbine driven, 1800 r.p.m.	Henry R. Worthington
2	Turbines	Single stage		Hot well pumps	1800 r.p.m., 180 lb. steam	Terry Steam Turbine Co.
2	Heaters	Open	5000 hp	Boiler feed water	Auxiliary exhaust	Harrison Safety Boiler Works
2	Pumps	Comp. duplex	9x14x8½x15 in	Tank service	Non-condensing	Henry R. Worthington
2	Pumps	Four-stage	4-in.	Boiler feed	3000 r.p.m., 15 ft. head suction	Jeanesville Iron Works
2	Pumps	Air	12x31x18 in.	With condenser	28½ to 29 in. vacuum	Laidlaw-Dunn-Gordon Co.
2	Turbines	Horizontal	50 hp	Driving boiler feed pumps	180 lb. steam, 3000 r.p.m.	General Electric Co.
1	Tank	Steel	35,000 gal. cap	Make-up and gen. utility water	Head on heaters and for house service and gland water	Henry Vogt Machine Co.
1	Pump	Duplex	20x12x15-in.	Boiler feed, house or fire	Can be used for station service	Henry R. Worthington
8	Boiler	Water tube	567 hp	Steam generator	200 lb. pressure, 125 deg. superheat	Babcock & Wilcox
8	Superheaters	Babcock & Wilcox	125°	Superheating steam	125 deg	Babcock & Wilcox
1	Chimney	Brick, red radial	255 ft. high, inside dia. 13 ft.	Flue gases	Natural draft	H. R. Heinicke
2	Elevators	Platform	6000 lb. cap.	Elevating bunker coal	Motor operated	Abell Elevator Co.
1	Motor	Direct current	30 hp	Elevator service	Direct current, 550 volts	Westinghouse Elec. & Mfg. Co.
1	Motor	Air current	30 hp	Elevator service	Three-phase, 25-cycle, 440 volt	Westinghouse Elec. & Mfg. Co.
	Pipe covering	Magnesia and asbestos	Various	Piping		H. W. Johns-Manville Co.

Two 4-in., four-stage boiler-feed pumps, each driven by a 60-hp. steam turbine, are placed in the 12-ft. high bay formed by the projection of the boiler-room floor and under the two 5000-hp. feed-water heaters, as shown at the right of Fig. 2. This arrangement gives a head for the boiler-feed pump of about 15 ft. as the heaters are supported 3 ft. above the boiler-room floor.

A 20 and 12 by 15-in. duplex reciprocating pump in the pump pit between the future Nos. 3 and 4 turbine units is so piped that it may be used for boiler feed, for boiler service, or for 300-lb. pressure fire service. The suction connects with the two concrete water intakes. All pump suctions are so piped that they may take water from the city mains if necessary.

In the bay formed under the boiler-room floor are two dry-vacuum pumps of the single, horizontal center-crank, double-flywheel type, equipped with Meyers steam valve-gear and Cincinnati air-valve gear.

* * *

Ammonia Pipe Fittings

By Gilbert Crawford, Jr.

SYNOPSIS—Describes the chief types of ammonia fittings in general use. Tells how to connect them and what troubles to expect when using the different kinds.

* * *

To the novice in a refrigerating plant, the ammonia-pipe fittings are a puzzle to be solved only after considerable study. The confusion is caused by the many types of fittings used in different plants, and sometimes in different parts of the same plant. Some of the types outwardly resemble each other, but are not constructed alike.

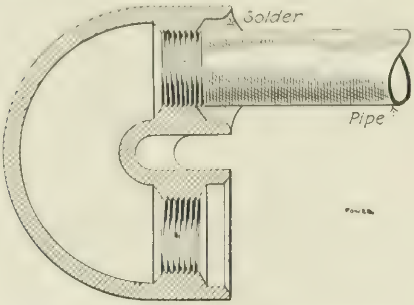


Fig. 1. Return Bend; Note Solder

There is no standard type of ammonia-pipe joint, and unfortunately, the fittings from the different manufactures, even though of the same type, are not interchangeable. An effort is being made to accomplish a standardization, but, on account of the great manufacturing outlay involved, it is doubtful if much can be done toward this end.

Ammonia under pressure is very penetrating, and in refrigerating apparatus particular pains must be taken to prevent leaks; they are not only disagreeable, but also expensive. Wherever a pipe screws into a fitting there is the possibility of a leak. This joint must be made tight, and in the flanged fitting, the joint between the flanges must be made tight as well. These are the two places where, in the ordinary plant, leaks may develop.

There are in wide use four general types of pipe fittings for ammonia work, as follows:

1. Screwed fittings.
2. Screwed fittings with gland.
3. Tongue-and-groove flanged fittings.
4. Boyle flanged fittings.

The first and third are used the more extensively, but the second and fourth have important applications. While there are other types on the market, they do not rank with these four in importance, though some are ingenious on paper.

Taking up the screwed fitting first, one sees (Fig. 1) that it is similar to the ordinary water- or steam-pipe fitting, but it is built on stronger lines and has a recess for solder. The joint between the pipe thread and the fitting thread is made tight in a variety of ways. The cheapest method is to cover the threads (especially the thread of the fitting, since the pressure is internal) with litharge and glycerin and screw the two together. This mixture, when proportioned properly, "sets" hard and the joint is satisfactory when well made. A much better method is as follows:

After screwing the pipe into the fitting to a hard grip, the fitting and pipe are heated at the joint, acid or soldering salts are applied, and the recess is filled with solder. Care must be taken that the solder sticks perfectly to both pipe and fitting, for on this depends the tightness of the joint. On this account the pipe is usually ground or filed bright, back of the thread, so that there will be no reason for the solder not adhering.

Another way of making a tight joint is to "sweat" the pipe into the fitting. This process consists in first tin-

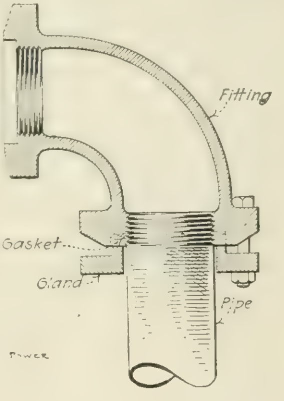


Fig. 2. Elbow with Loose Flange and Gasket

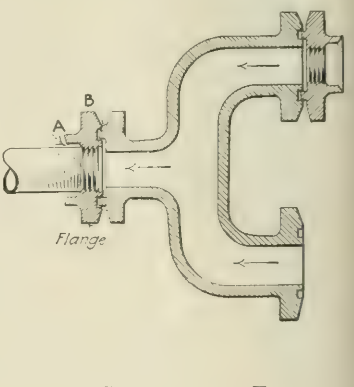


Fig. 3. Showing the Tongue and Groove Joints

ning the threads of the pipe and fitting and screwing the two together while hot, immediately filling the recess with molten solder. When properly made this joint is most satisfactory.

A word is not out of place here as to the material used in making screwed fittings for this class of service. As cast iron cannot readily be tinned, and as it is somewhat porous and brittle in comparison with other preferred metals, it is used but little for ammonia screwed fittings. Instead, malleable iron and semi-steel are used. Solder will adhere to them, and they are, especially the former, far more ductile than cast iron. For pipe couplings, wrought iron is sometimes used.

The screwed fitting with a gland is shown in Fig. 2. It differs from the plain screwed fitting in that the joint is made tight by a gasket. Instead of using a grommet or solder, usually a rubber gasket is placed in a recess of the fitting, and a gland, nearly always tightened by bolts, as in Fig. 2, holds the gasket in its place. The gland and the gasket act as a stuffing-box. When first put together, a solid ring gasket is used, and for renewals a split ring. The use of the latter saves unscrewing the pipe from the fitting. A leak in such a joint is easily stopped by drawing up on the bolts.

The standard type of tongue-and-groove fitting is shown in Fig. 3. This is a different fitting as it is flanged, and two points are to be made tight with it, at *A* and at *B*. The joint *A* is between the pipe and the flange and *B* is the joint between the flange and the fitting proper. The joint *A* may be made tight by the use of either solder or litharge. The joint at *B* is tightened by a washer set into the groove and held there by the tongue. The flange on the pipe is held against the flange of the fitting by bolts; the fittings are usually made tongue on one end and groove on the other. The washer is generally of lead or fiber, but may be of rubber in installations where there is vibration.

In Fig. 4 is shown a tongue-and-groove flange union. Two flanges, one tongued and one grooved, are bolted together, with a washer between. These flanges are sometimes made of drop-forged steel.

In laying out pipe lines using tongue-and-grooved fittings, it is customary to have the gas flow through the fitting from the groove to the tongue, where the choice is at will. This rule is sometimes excepted when the pipe line is vertical (the planes of the flanges horizontal) when the grooved flange is the lower of the two, to enable one to more easily place the washer in position.

The Boyle fitting (all ends tongued) is shown in Fig. 5. This type lies in the flanged class. The joints at *A* and at *B* are made tight with one gasket, usually of rubber. The gasket is placed in a recess formed by the flange and the end of the pipe, as shown. The tongue end of the fitting is held against the gasket by bolts connecting the pipe flange to the fitting flange, and by drawing up on the bolts, both joints are made tight. With the Boyle joint it is not necessary to have the pipe screwed tight into the flange; in fact, the flange is usually tapped with a uniform (nontaper) thread, which does not allow of a tight-screwed joint. Entire reliance against leakage is placed on the gasket.

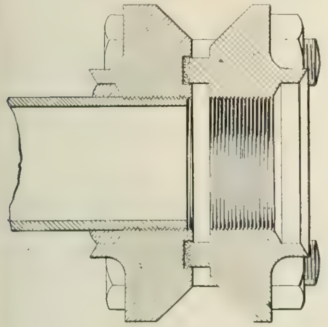


FIG. 4

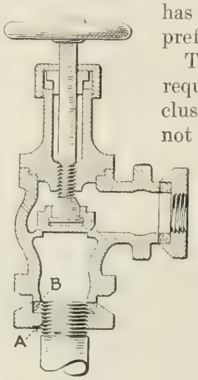


FIG. 5

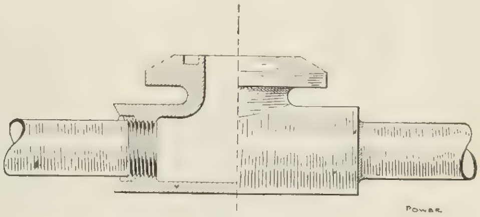


FIG. 6

SECTIONAL VIEWS OF AMMONIA FITTINGS: NOTE CHARACTER OF JOINTS

There is also a sort of hybrid type of fitting, partly flange and partly screw, an example of which is shown in Fig. 6. Such fittings are useful for many purposes.

A comparison of the different fittings is difficult. Each has its advantages, each its disadvantages, and individual preference enters, as in all such cases.

The screwed fitting is the cheapest, is the lighter, and requires less machining, but a pipe line made up exclusively of screwed fittings is a poor affair. A leak cannot be repaired or an alteration made without perhaps taking down half the line, and the entire line must be made up on the job, which makes the soldering of the joints impracticable.

The screwed fitting with glands makes a tight joint, and is applicable on long pipe lines, such as street mains, where the gland is used as an extra precaution; entire dependence is not placed on the screwed joint. It will be noticed that the gland type allows of a certain amount of flexibility, sharing this distinction with the Boyle fitting, in that it can be turned somewhat on the pipe, even with pressure therein, the rubber gasket maintaining the joint. Like the plain screwed pipe line, a line made up of gland fittings exclusively cannot be taken down at any point. If a leak occurs at a joint, however, it can be stopped by tightening the gland.

The tongue-and-groove fitting admits of easy accessibility as the piping may be disconnected at any joint. The same may be said of the Boyle, although both are more expensive.

The Boyle flanged fitting has one disadvantage which about offsets its many good points. The pressure on the gasket created by the tightening bolts will cause the rubber of the gasket to creep slowly past the pipe thread on the end of the pipe, into the pipe system; this causes accumulations and stoppages. On the hot gas lines, the heat and pressure decompose and soften the rubber, and blowouts occur.

Where rubber is used as a gasket, it is occasionally necessary to "follow up" on the bolts to stop leaks. It is, therefore, questionable practice to place rubber-packed joints in places where leaks are hard to detect, such as freezing tanks, submerged condensers, etc.

To take advantage of the lower cost of screw-end fittings and yet have a simple pipe line to construct or change—one that may be largely made up in the shop—it is sometimes customary to use screw-end fittings with occasional flanged fittings. When pipe lines are thoughtfully laid out according to this combination system, the results are most satisfactory.

It is well to mention that the welding processes have found one of the many applications to the field of ammonia-pipe work. First-class headers and branches are constructed by their application, at a fraction of the cost if made up with fittings. The joints are eliminated and the whole job is neater and lighter.

*

A Heating Boiler Explosion

The energy and capacity for doing damage lurking in a domesticated and harmless-looking cast-iron boiler is underestimated by most of those who have to do with them. The effect of the explosion of a cast-iron boiler is shown by the photographs reproduced. This accident occurred in St. John's Church, Des Moines, Iowa, on Mar. 2 at 11 o'clock at night. "The loss," a member of the council states, "will be from $10,000 to $12,000, with no insurance, but we are thankful that no one was killed or seriously injured." The attendant had left the building about an hour before.

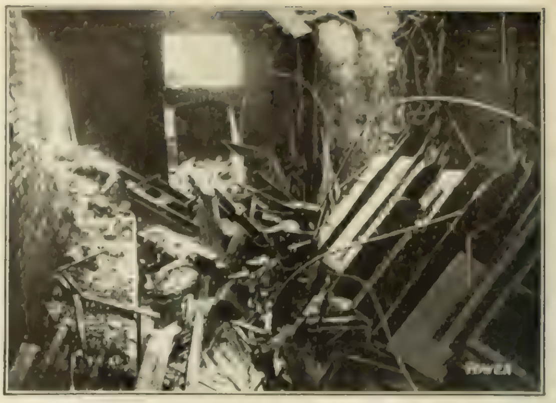


Fig. 2 View in the Boiler Room

From the reports at hand, it appears that the boilers had not been behaving properly all winter and it is likely that an intelligent inspection would have revealed the fault, which might then have been remedied and the accident averted. The exterior view of the church, Fig. 1, shows the high windows damaged, which indicates the force and far-reaching effect. Fig. 3 shows a brick wall

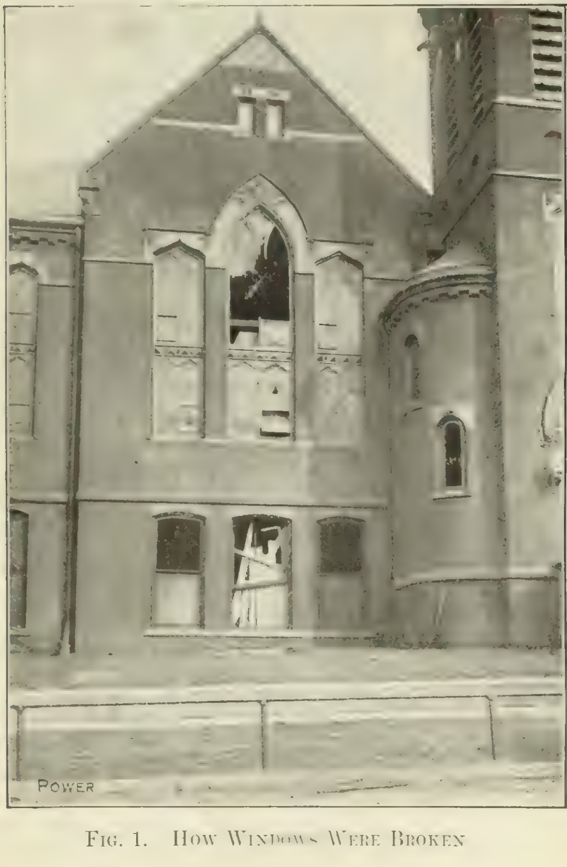


Fig. 1. How Windows Were Broken

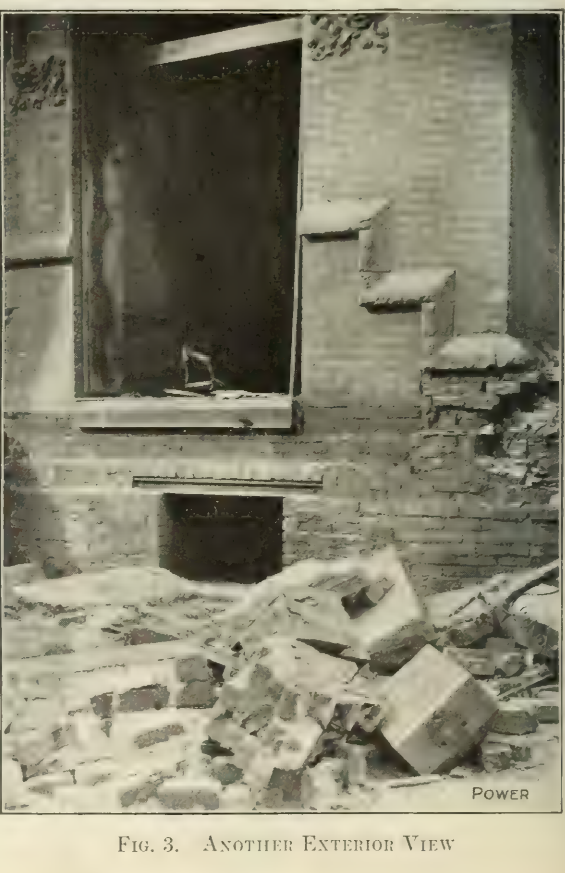


Fig. 3. Another Exterior View

demolished. Fig. 2 shows the boiler room. As a whole, the damage seems entirely out of proportion to the size and pressure usually carried on boilers of this class. That there are frequent faulty installations of domestic heaters is well known. That it is international is shown in a British Board of Trade report, from which we quote the following regarding a somewhat similar accident.

> The explosion was caused by over-pressure of steam, due to over-firing, there being no adequate means of relieving the boiler of such pressure.
>
> We think the owners are responsible for the following reasons: (1) No safety valve, or other sufficient means were provided for relieving the boiler of steam pressure. (2) The management of the heating apparatus was not intrusted to a person with sufficient experience, and no printed or written rules were supplied to him. (3) The boiler was not periodically or at all inspected, as it should have been, by a qualified person. (4) No proper measures were taken by the owners to insure that the boiler was worked under safe conditions.
>
> The firm described as "ironmongers, plumbers and sanitary engineers," we think is partly to blame for the explosion, as no sufficient means were provided for relieving the boiler of steam pressure. Further, we think that the duty of those who install boilers is to take all precautions to prevent persons being injured by explosions. This being their duty, it is no answer to say the explosion would not have happened if the boiler had not been over-fired.
>
> Boiler explosions are nearly always due to preventable causes, and there was certainly no unavoidable cause in this case. We think the explosion would have been averted by reasonable precautions and by the exercise of ordinary care in the installation, inspection and supervision of the boiler. This is not the first explosion, of the boiler of a heating apparatus having no safety valve, which has been attended by loss of life.

⁂ ⁂

Evaporative Tests with Oil as Fuel

By Charles Jablow

SYNOPSIS—Evaporative efficiency of different oils after deducting steam for atomizing.

⁂

During the past few years tests have been conducted by the engineering division of the Oklahoma Agricultural and Mechanical College to determine the economic use of some of the grades of coal and oil which are available in this vicinity. Some recent investigations have been carried on to obtain a comparison of different oils when used as a fuel under a 200-hp. B. & W. boiler equipped with a Peabody oil furnace. The comparison was to determine the evaporative efficiency of the different oils, when the amounts of steam for atomizing were taken into account. This consideration gives rise to the two terms, which will be used later, "gross and net boiler efficiency." The gross efficiency is represented by the quotient obtained by dividing the heat given up to the feed water per pound of oil, by the total heat contained in one pound of the fuel. To obtain net efficiency the amount of steam required for atomizing is subtracted from the amount evaporated before making the above division.

In the usual system of burning oil under a boiler, the burner is at the front and the flame is directed against the brickwork at the bridge-wall. This is to prevent any excessive local heating of the tubes or boiler shell. In the system under discussion the burner is located at the bridge-wall, which is about half the length of the setting from the front. The flame is directed toward the front of the setting. By this method there is no excessive local heating and the flame is not permitted to come in contact with the outer walls of the setting or exposed metal of the boiler. It also provides a sufficiently long travel for the gases so as to insure complete combustion. The boiler used in this test has been installed within the last few months and was perfectly clean and tight. The fittings were also all new.

To insure the greatest accuracy the meters that were used on the oil- and feed-water lines were carefully calibrated before placing in the line. A separate boiler was used to supply steam for the burners and the required amount of water to keep a constant level in the gage-glass of this second boiler was recorded. An individual tank, pump and oil line, was used so that the oil under test should not become mixed with that used in the plant, as the latter supply was drawn from the large supply tank, which is a mixture of various oils added from time to time. The tank used for the test had a capacity of 425 gal., a sufficient amount to cover the period of any one test.

Before the test tank was filled, oil was permitted to flow from the tank car for several hours so that the line to the siding should be well cleaned of other oil and that a nearer average sample could be collected. Another precaution in the test was to proportion the air admitted so that no smoke should be perceptible and still not allow an excess of air. The results of the tests are tabulated in the accompanying table.

Results of Tests

	Crude	Fuel
Average duration of tests, hr.	3.5	4.125
DIMENSIONS		
Grate area, sq.ft.	60	60
Heating surface, sq.ft.	1870	1870
Area smoke stack at top, sq.ft.	23.8	23.8
Height of stack, ft.	125	125
Ratio heating to grate surface	31.2	31.2
PRESSURES		
Steam pressure, gage, lb.	112	101.7
Draft in breeching, in. of water	0.109	0.128
TEMPERATURES		
Boiler room, deg. F.	76.5	77.5
Feed water, deg. F.	145	165
Flue gases, deg. F.	352	307.5
Oil to burners, deg. F.	75.2	153
FUEL		
Total weight of oil fired, lb.	1783.8	1560.3
Heating value per lb., B.t.u.	22,115	18,652.5
Specific gravity at av. temp. 78 deg	0.808	
Specific gravity at av. temp. 81 deg.		0.877
Degrees Baumé at above temperatures	44	30
Fuel burned per hour, lb.	509.7	378.3
WATER		
Total weight fed to boiler, lb.	25,974	22,046.5
Weight fed to auxiliary boiler for steam to burners, lb.	780	1255
Per cent. of total steam generated used to atomize oil.	3.1	5.91
Water per hr., lb.	7421	5344.6
EVAPORATION CORRECTED FOR QUALITY		
Quality of steam, per cent.	96.8	96.3
Total weight evaporated from feed water temperature, lb.	25,150	21,230
Total equivalent evaporation, lb.	28,000	23,140
Factor of evaporation	1.112	1.089
Equivalent evaporation per hr., per sq.ft. heating surface, lb.	4.28	3.00
Equivalent evaporation per hr., lb.	8000	5610
Actual evaporation per lb. of oil from feed temperature, lb.	14.09	13.61
Equivalent evaporation per lb. of oil, lb.	15.65	14.83
HORSEPOWER		
Horsepower developed	231.9	162.61
Builders' rating	200	200
Per cent. of rated horsepower developed	116	81.3
EFFICIENCY		
Boiler efficiency not accounting for steam used in atomizing, per cent.	68.6	77.1
Boiler efficiency accounting for steam used in atomizing, per cent.	66.7	72.6

Too much weight should not be given to the equivalent evaporation per pound of oil without considering other factors at the same time. In the results attention might be directed to the amounts of steam used in atomizing and the effect this has on the net efficiency of the boiler.

The average cost at the storage tanks of the oil companies, for the crude oil was 98c. per barrel of 42 gal. For the fuel oil the average cost was 82c. In a study of the tabulated results, it will be seen that while the use of the fuel oil is more economical, the difference is not as great as is represented by the costs per barrel. If the above test had been made in colder weather, the results would probably show slightly more favorable to the use of crude oil on account of the steam used in atomizing.

On account of the fact that enough attention is not given to the amount of steam used in spraying oil in oil burners under boilers, the following is included. It is not alone the cost of water, for this may not be a considerable item, but when the cost of evaporating this water into steam is considered, methods of oil burning may receive closer attention.

Figuring on a basis of an equivalent evaporation of 15 lb. of water per pound of oil and 5 per cent. of the steam generated to be used for atomizing: one pound of oil would be expended in atomizing, for each 300 lb. of steam generated from and at 212 deg. F. For other values substitution can be made in the equation:

$$X = \frac{100\,E}{A}$$

where

X = Evaporation from and at 212 deg.;
E = Equivalent evaporation per pound of oil;
A = Per cent. of X used for atomizing oil.

For the example taken above the cost of atomizing, when developing 100 hp.

$$100 \times 34.5 = 3450\ lb.$$

of steam are evaporated and this would require for atomizing

$$3450 \div 300 = 11.5\ lb.\ of\ oil$$

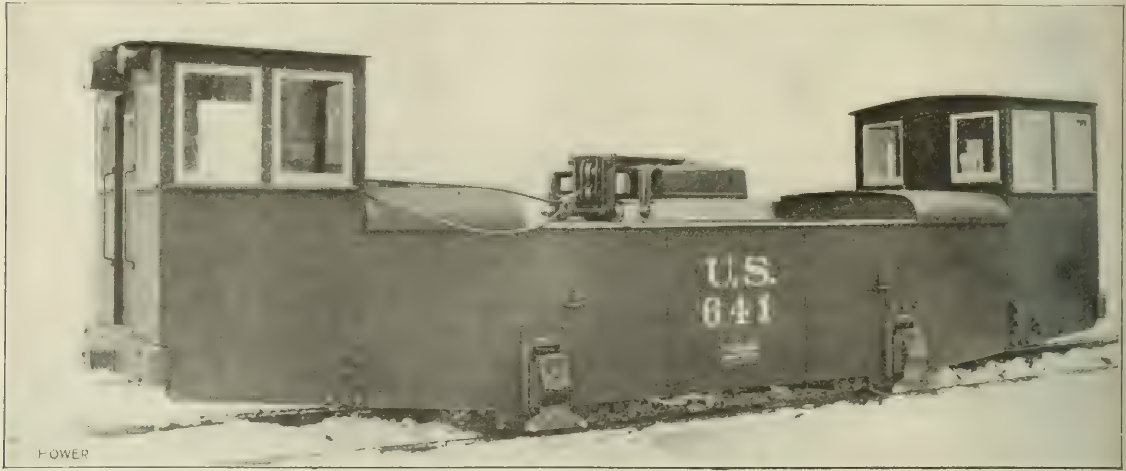
The above formula can be modified to give results in pounds of oil used for atomizing per horsepower developed, if the boiler performance and the amount of steam used for atomizing are known. The equation would read

$$O = \frac{34.5\,A}{100\,E}$$

where O = pounds of oil used for atomizing for each horsepower developed.

⁂

Locomotives for Panama Canal



Towing Locomotive for Panama Canal

The photograph shows one of the 40 electric locomotives which the General Electric Co. is building for the U. S. Government to be used in towing ships through the Panama Canal locks. Each machine weighs 82,500 lb. and has a tractive effort of 47,500 lb. This power is derived through two 75-hp., three-phase, 25-cycle, 220-volt, mill-type motors, one connected to each axle through gearing.

The locomotive is propelled by means of a rack rail while towing and while going up and down the steep grades from one lock level to another at a speed of two miles per hour. When running light on the return tracks, the speed is changed to five miles per hour, the rack pinion being entirely released and the locomotive proceeding by ordinary traction methods.

Reference to the photograph will show a vertical windlass and drum at the center of the locomotive; this carries 800 ft. of 1-in. steel hawser for towing. Ordinarily four locomotives will be required to put a ship through a lock; two on each side, the forward pair pulling and the astern pair guiding the ship. With very large vessels it may be necessary to employ six locomotives.

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Sarco Room-Temperature Regulator and Mixing Valve

A temperature regulator, based on the use of liquid expansion operating an elongated corrugated diaphragm,

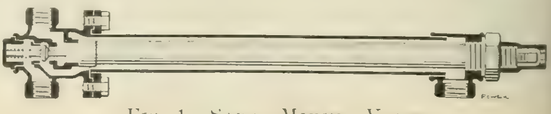


Fig. 1. Sarco Mixing Valve

is being placed on the market by the Sarco Engineering Co., 116 Broad St., New York City.

The room-temperature regulator, Fig. 2, is substantially of three parts: The thermostat, which is mounted on a board and exposed to the atmosphere, the temperature of which it is desired to control; the controller and the valve.

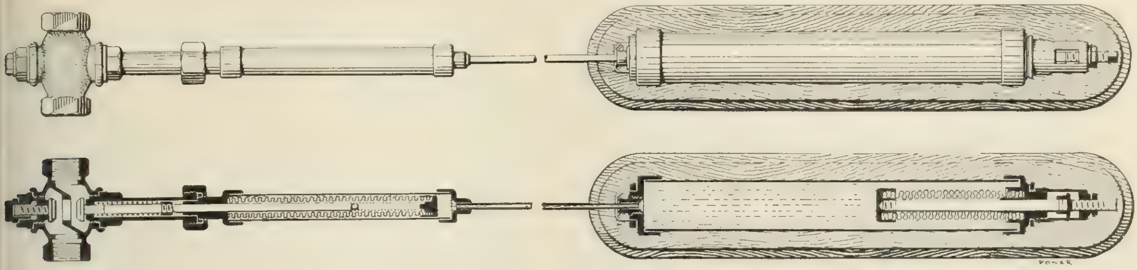


FIG. 2. SARCO ROOM TEMPERATURE REGULATOR

The thermostat is practically a cylinder containing a heavy oil, the capacity of which is varied by regulating the extension of a corrugated tube. When the temperature of the air rises, the liquid in the thermostat expands and produces a considerable pressure in the thermostat, which is transmitted by a fine copper tube to the controller, there compressing another corrugated tube, which when contracted, forces out a piston, tending to close the valve. When the temperature falls, the process is reversed and the valve is opened, thus regulating the supply of steam or hot water used to maintain the temperature required. The regulator is self-contained and supplies its own motive power, without outside sources of energy.

Another device using the same principle is the Sarco mixing valve, Fig. 1, an apparatus which produces the continuous discharge of water at a constant temperature. This device is so constructed that hot water or steam is supplied at one side and cold water on the other. In the mixing chamber within the valve there is a cartridge which controls the size of the hot-water or steam inlet. The discharge water is thus maintained at a predetermined temperature, which, it is claimed, will not vary 1 deg. under ordinary conditions, hence any desired temperature may be obtained.

* *

Purchasing Boilers--I

BY J. E. TERMAN

SYNOPSIS—If you were to purchase a steam boiler, would you know how to specify what features were to be incorporated in its design? Would you know what features are or are not desirable? This article gives a number of points, and the procedure to follow in purchasing boilers.

*

It is intended that this article will aid the purchaser of boilers who buys one or two at a time. The purchaser of many boilers can afford to hire a competent consulting engineer to look after his interest, if he has not already in his plant an engineer capable of handling the subject. When a consulting engineer is engaged, the purchaser should make certain that he is capable and then follow his advice implicitly.

If additional boilers are bought and added to an existing small plant, it is probably because the plant engineer, who may possibly have little theoretical steam-engineering knowledge, complained of the difficulty of maintaining the desirable steam pressure until the management finally decided to purchase additional boilers.

The complaint in practically all such cases is proper, for the engineer is in a position to know the difficulties of operation. It is also almost certain that remedying the conditions of which he complains will result in economy. However, it should be understood by the management that an apparent lack of boiler capacity is often remedied by means other than by the purchase of additional boilers.

DRAFT AND GRATE AREA

The fundamental feature of boiler-plant capacity is the ability to burn an amount of fuel sufficient to generate the steam required. This ability to burn fuel depends primarily on two things, draft and grate area, and both of these factors have to be adjusted according to the kind of fuel used. The question of grate area is usually, in a measure, cared for by the boiler manufacturer, but the stack capacity may be inadequate in a plant using one stack for all boilers, and where the boiler capacity has been increased since the initial installation. For instance, the original equipment may have consisted of two or three boilers and a stack capacity to barely suit their needs. Therefore, any addition to the boiler equipment would overload the stack. Often, under such conditions, the original boiler capacity has been doubled or trebled without any change in the stack capacity. In such aggravated cases the addition of a boiler will actually reduce the plant capacity.

The owner who contemplates purchasing additional boilers should satisfy himself that his apparently insufficient boiler capacity is not due to lack of chimney capacity, either as regards the intensity of draft or volume, or to lack of proper grate area.

With the finer grades of anthracite coal usually sold for power purposes, it is practically impossible to burn enough fuel with ordinary stack draft to operate a boiler at its normal capacity. However, there are many small plants burning this grade of fuel with natural draft, the owners of which will add to the boiler equipment when needing more steam, without considering the use of artificial draft. The installation of a blower in such cases would often enable the burning of enough coal to operate the boilers efficiently and relieve the condition diagnosed as lack of boiler capacity.

Another feature that should be determined before purchasing additional boiler equipment, is whether the steam generated by the boilers on hand is economically used or not. In plants using a single engine and where no steam is used for heating coils, etc., determining the efficiency of the use of the steam is relatively simple. Tracing its efficient use is more difficult with engines scattered about the plant, large radiation losses, and steam used for other than power purposes.

Are Additional Boilers Required?

The best method to pursue when contemplating the purchase of additional equipment, even for the small plant, is to have a reliable consulting engineer look into the plant conditions to determine if additional boilers are actually required, or if changes in operation cannot be made which will obviate the necessity for new boilers.

While this course may seem expensive in the average case, the chances are that an investigation will reveal conditions which will, when rectified, result in enough saving in future operation to pay a handsome profit on the engineer's fee, even if additional boiler equipment is required.

The consulting engineer may show that more boilers are not necessary, in which event, their cost and the interest on the investment are saved, in addition to the economy gained by the changed operating conditions that rendered new boilers unnecessary.

If, on account of any of the numerous reasons which deter the management from employing a consulting engineer, it is decided to take chances and settle the question unaided, the following suggestions may be of service in deciding the question of purchasing additional boilers: First, find out how much heating surface in square feet is contained in the boilers already installed, which need not be done with extreme accuracy. If the boilers are of the horizontal tubular type, the calculations may be made as follows:

To find the heating surface of each boiler, add the combined diameters of all tubes, in feet, to one-half the diameter of the boiler shell in feet, and with their sum as a diameter find the circumference of the corresponding circle. Multiplying this circumference by the length of the tubes in feet will give the heating surface in square feet.

For example, a 72-in. boiler, 18 ft. long, contains 70 four-inch tubes. The combined diameter of the tubes is

$$\frac{70 \times 4}{12} = 23.3\ ft.$$

One-half the diameter of the shell is 3 ft., then the total diameter is 3 + 23.3, or 26.3 ft. The circumference of 26.3 diameter is 82 ft., and 82 × 18 is 1476 sq.ft. of heating surface.

If bituminous fuel is used, every foot of the heating surface should evaporate from 3.8 to 4 lb. of water per hour, when forced, and if the maximum, not average, rate at which steam is required does not equal or exceed this amount, some other cause of deficient steam supply should be looked for.

Grate Area and Heating Surface

Under average conditions in the small plant, ½ lb. of coal should be burned per square foot of heating surface per hour to evaporate, say, 4 lb. of water into steam. If it is found that this amount of coal cannot be burned, the draft conditions should be investigated or the available grate surface be looked after. With ordinary chimney draft, it is usually difficult to burn good bituminous coal at a rate higher than 20 to 25 lb. per sq.ft. of grate surface per hour; 20 is fairly easy to obtain, but 25 lb. are generally difficult.

If the proportion of the grate to the heating surface is such that much over 20 lb. of fuel are burned per square foot of grate per hour to get the maximum results from the heating surface, then the grate surface requires enlarging. If the rate of coal required to be burned per square foot of grate surface per hour is not over 20 lb. to give the maximum capacity for the heating surface available, as already estimated, and the pounds of steam required per hour, divided by the number of square feet of heating surface, is not over four, then the draft conditions should be investigated.

It must be understood that the foregoing are about the maximum rates under average conditions in the small plant and can be used as a guide to tell whether there is some glaring deficiency in the available heating surface or grate surface in an existing plant.

Measuring Draft

A good grade of bituminous coal in a plant with average surroundings requires a stack from 100 to 125 ft. high to afford ample draft. A cross-sectional stack area of about 4 sq.ft. for the first 1000 sq.ft. of heating surface and 3 sq.ft. for each additional 1000 sq.ft. is required to give the proper volume of draft. The draft in inches of water, with a stack of the height and area as indicated, under operating conditions, should be about ⅝ to ¾ in. at the base of the stack and ⅜ to ½ in. in the furnace over the fire.

A plant may be provided with a stack of ample height and area and still be unable to burn the required amount of fuel, owing to improper connections, either as to shape or size, between the boilers and the stack. Therefore, the measurement of the effective draft over the firebed with the fire-doors closed and the damper and ashpit doors wide open is the real test of whether the draft conditions are proper for the grate surface. The measurement of the draft should be taken when all the boilers that the stack is supposed to serve are operating.

Type of Boilers To Be Selected

After deciding that new boilers are necessary, what size and type should be adopted? Since this article is only intended to cover the average case for the small plant, the type of boiler could be eliminated and it be assumed that the horizontal, return-tubular boiler would be used. However, some of the general features of a few other types will be discussed.

The water-tube boiler is made in so many forms that it is difficult to say much, in a general way, about them. They are capable of carrying a high steam pressure, and if pressure above 150 lb. is desired, the water-tube or he vertical tubular boiler would be used, in most cases.

If a water-tube boiler is to be used, select a simple esign. The average purchaser should pay no attention o high-brow theories in regard to circulation and effiiency; he should buy a boiler that is so designed that it an be repaired and cleaned without being torn down. There are, however, points connected with the proper esign for efficient operation that are worthy of conideration, providing that accessibility has first been atained.

Few small plants will be interested in the water-tube oiler, because the first cost is approximately 50 per ent. above that of the return-tubular and its mainnance requires more skill and costs more. The life of uch boilers is usually much shorter than that of the orizontal tubular type.

The vertical tubular boiler, particularly in sizes of 150 o 250 hp., is an excellent one for power purposes, being ow in first cost, slightly under the horizontal tubular, nd is economical to operate. It does away with bricketting repairs, and is capable of being built for high ressures. This type, however, has one serious drawack, which is that the crown-sheet is extremely sensive, and unless the feed water is of the best quality for oiler purposes, this type should not be considered.

The locomotive type is sometimes used in small plants, ut little can be said in its favor. It is high in first ost, fairly efficient, extremely costly to repair, a repair f any magnitude in the firebox costing practically as uch as the boiler; it has some advantage where head oom is limited, or where the location of the boiler is onsidered temporary.

The horizontal tubular boiler is the type most freuently used in the small plant, and has the most advantages under general operating conditions. It is easily cleaned and repaired; it requires the least skilled attention of practically any boiler, and it is about equal in efficiency to any when boilers of equal capacity are compared.

A feature that should be considered in purchasing boilers to add to an existing plant is that the men have become accustomed to the type already in use, and if the boilers have given satisfactory service there should be some good reason for making a change. It will be assumed, therefore, that the horizontal return-tubular boiler is to be adopted and the rest of this article will refer to that type.

Size of Unit to Be Adopted

The size of unit to be adopted depends largely upon the plant conditions. If it is at all practicable, every plant should consist of a minimum number of two boilers.

Generally, the larger the boiler the more economical its operation and, if the size of the plant will stand three or more large units, boilers of 78-in. diameter and 18-ft. length are a good size to adopt. This size represents about the maximum capacity for the type, and, although much larger sizes are built, it is doubtful if they have demonstrated their worth.

The diameter of this type is limited by the thickness of the sheet necessary to use for the pressure desired. It has been demonstrated by trial that a $\frac{5}{8}$-in. sheet is practically the limit for externally fired boilers, and even this thickness is too great, except where good feed water is used and the best workmanship employed. Boilers are occasionally built with thicker sheets and the edges of the plate at the girth seams are planed or milled down, but it is doubtful if this construction is justified, and it remains to be proved that it represents good practice.

Some Common Transformer Connections

By Norman G. Meade

Among the advantages of alternating-current distribuon is the facility with which the potential, current and hases can be changed by different combinations of transrmers. For single-phase work, transformers can be nnected so as to change any current and voltage to any her current and voltage within practical limits. In a ultiphase system, in addition to these changes, the hases can be changed to almost any form desired.

The common methods of connecting transformers to ngle-phase, constant-potential mains are shown in Fig. Practically all distributing transformers have primary d secondary windings made up of two coils each, to cure a flexibility of voltage combinations. Either the imary or the secondary coils, or both, may be connected series or in multiple. At *A*, in Fig. 1, the primary ils are connected in series and the secondary coils in ultiple to secure a 2200-volt to 55-volt transformation. t *B* both the primary and the secondary coils are concted in series for a 20-to-1 transformation. For resince lighting, the most economical method of supply is rough single-phase transformers with three-wire secndaries. A tap is brought out from the middle of the condary winding which is connected to the neutral wire of the three-wire system. In this way a few large transformers can be connected by three-wire secondaries in a residence or other district and will take care of a large number of connected lamps. Such an arrangement of transformer connections is shown in Fig. 2.

A modification of the three-wire system is shown in Fig. 3, in which the outside wires of the secondary system are fed by a single transformer and the neutral wire is taken care of by a balancing transformer connected at or near the center of distribution. The effect of the balancing transformer is similar to a motor-generator balancing set—that is, the voltage of the heavily loaded side of the three-wire system is boosted to compensate for the excessive voltage drop on that side, owing to the unbalanced load conditions. The capacity of the balancing transformer need be only half the greatest variation in load between the two sides of the system.

Where the ratio of transformation is not greater than 2 to 1, auto-transformers can be used to advantage in place of the regular transformers. In effect, these are the same as balancing coils. In Fig. 4, *A* shows a three-wire secondary or distribution system fed from a 220-volt main and so arranged as to give a potential of 110 volts between the neutral wire and the outside wires. At *B* the secondary system is essentially the same, but the primary main has a potential of only 110 volts, the autotransformer in effect giving the same result that would be secured if an ordinary transformer having a 110-volt primary and a 220-volt secondary were used.

The plain two-phase or quarter-phase connection shown in Fig. 5 is simply two single-phase transformers connected to their respective phases, the phases being kept entirely separate. In three-wire, quarter-phase work one of the secondary leads can be used as a common return, as in Fig. 6.

The three-phase connections shown in Fig. 7 are known as delta connections and are of advantage where continuity of service is important. The removal of any one transformer does not interrupt three-phase distributio and the removal of two transformers still admits of powe transmission on a single-phase of the circuit. Where on transformer is removed, however, each of the two remain ing ones must carry 1.73 times the original current fo the same load and the internal losses in this case wi be greater.

The *Y* or star connection shown in Fig. 8 has one o the terminals of each primary and each secondary brough to a common connection, the remaining three termina being connected, respectively, with the supply and th

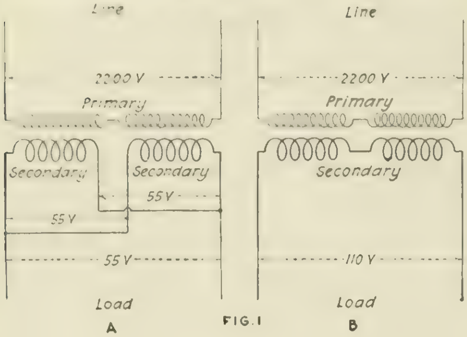


FIG. 1

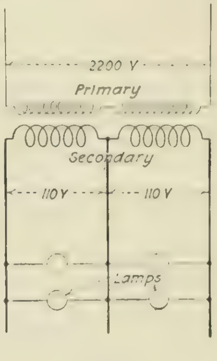


FIG. 2

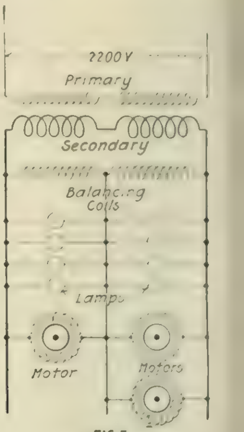


FIG. 3

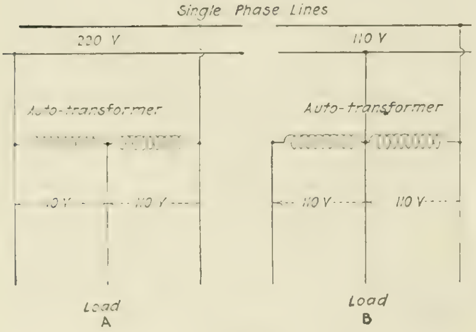


FIG. 4

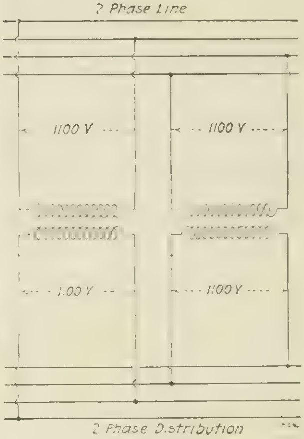


FIG. 5

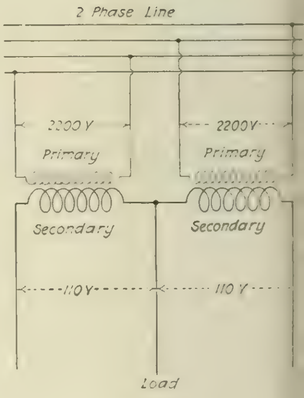


FIG. 6

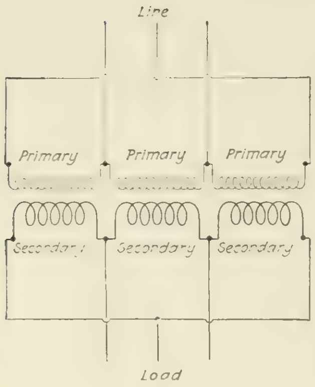


FIG. 7

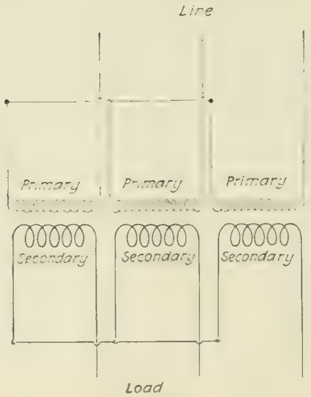


FIG. 8

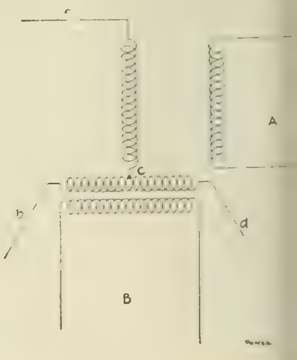


FIG. 9

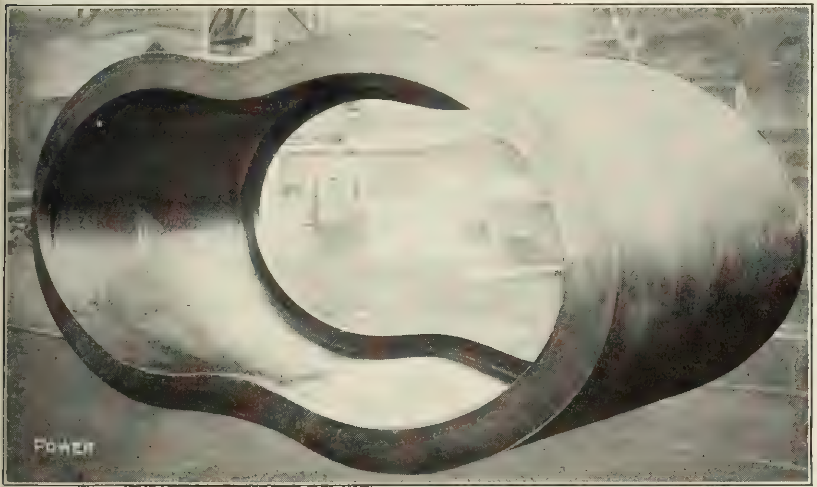
VARIOUS METHODS OF CONNECTING TRANSFORMERS distribution system. An advantage of this connection over the delta is that for the same transmission voltage each transformer is wound for only 58 per cent. of the line voltage.

Two currents differing in phase by 90 deg. may be transformed into three-phase currents differing by 120 deg., or *vice versa,* by using the combination shown in Fig. 9 and well known as the "Scott" connection. Two transformers, *A* and *B,* are connected to two-phase mains. The secondary coil of *B* is represented by *bd* and that of *A* by *ec.* The secondary coil of *A*—that is, *ec*—has 0.866 times as many turns as the secondary of *B* or, what amounts to the same thing, an 86.6 per cent. voltage tap is brought out from the secondary of *A,* to which the lead is connected The other end of the secondary of *A* is connected to a tap brought out from the middle point of the secondary of *B.* Therefore, the leads *bde* form a three-phase system, or if three-phase currents are applied, they will be transformed to two currents differing in phase by 90 deg. in the primary windings of *A* and *B.*

Turbine Casing Deformed

The photograph shows part of a casing for a large marine turbine. Originally, of course, the casing was cylindrical.

This casing is of German manufacture, the metal being supplied by a company other than the builders. The deformation test was made to demonstrate to the builders the quality of metal supplied. Although American engineers will perhaps question the merits of such a test, it is interesting as an example of the German's effort to be thorough.



Large Turbine Casing Deformed

Smoke Abatement in England

The progress of the movement for smoke abatement and fuel economy in Great Britain during the past 12 months, writes Consul-General John L. Griffiths, has taken the form chiefly of propaganda education and pioneer work in respect to improved methods of burning coal, for both factory and domestic purposes. In addition, steps are being taken to secure accurate measurements of atmospheric pollution. Fifteen of the largest cities have agreed to join in these experiments, and in London the work commenced in November last and is at present in operation. Owing to delay in securing the necessary soot and dust gages, the start in this work in all the 15 cities has had to be deferred until this spring. It is not expected that the comparative records will be available before the close of this year.

The cities which will undertake these observations are Birmingham, Bradford, Crewe, Exeter, Glasgow, Hull, Leeds, Leicester, Liverpool, Malvern, Manchester, Newcastle, Plymouth and York, in addition to certain London boroughs.

A bill has been drawn for introduction into Parliament to consolidate existing laws, as well as to provide local authorities with extended powers against the emission of black smoke. This is a private bill—that is to say, not a government measure—and as the supporters were not successful in the ballot for private members' bills, nothing will probably result this year, but the existence of the bill has created increased interest among smoke reformers, particularly as to the lines of future legislation.

The educational classes for engineers and firemen, started in several cities, continue to meet with growing success. The object is to develop properly trained bodies of skilled firemen, who, it is claimed, are essential to the solution of the black-smoke problem. The classes in Glasgow, which have been very successful, are carried on during the winter months at different populous centers, and are under the direction of smoke inspectors of the municipality. Each winter 100 to 200 firemen have been enrolled since the classes were inaugurated four years ago, and it is now proposed to start more advanced classes.

In connection with the subject of smoke abatement should be noted the greatly increased use of gas and electricity for domestic purposes. This is particularly the case in London and in provincial towns where gas is cheaper than coal. The rapid growth in this direction is so marked that it is believed by many that gas and electrical appliances will, to a great extent in the near future, take the place of coal grates and fires, and that those who prefer coal fires will use smoke-consuming grates or employ smokeless-coal substitutes.

While progress is constantly being made, it is necessarily slow because of the limited powers conferred by existing laws and the fact that societies for the suppression of coal smoke are dependent upon membership fees and donations for the funds required to carry on their work.

Accident to Ammonia Compressor

One man was killed and three injured, one of them very seriously, when the rear head of the ammonia cylinder was knocked from a refrigerating machine in the Hough Ave. plant of the Cleveland & Sandusky Brewing Co., Cleveland, Ohio. The wrecked machine was of 100 tons refrigerating capacity.

The accident occurred while the machine was being started up at 12:15 p.m., after a short shutdown. Chief Engineer James D. Bowman, at the throttle of the steam end, was struck by one of the flying pieces and so badly injured that he was suffocated before assistance could reach him. George Kilburn, assistant engineer, standing by the ammonia cylinder, had his right leg broken, but managed to get to a window and partly through it before he was overcome. More than one-half of the rear head of the ammonia cylinder, carrying the valve chests with it, gave way. The low-pressure ammonia line was broken in the tee connecting with the inlet valves, while the high-pressure line, which connected with the two lower valve chests by a tee below the cylinder, was carried away at the ceiling and thrown over the ammonia end, falling across the steam end, where it bent the governor and Corliss valve reach rods. The handwheel on the steam-throttle valve was bent over and one of the dashpot reach rods broken. Fig. 1 shows the compressor.

Fig. 2 shows the end of the ammonia cylinder and the line of the break. This cylinder consists of a spool-shaped casting which is bolted to a yoke-shaped seat on the bedplate by a longitudinal flange on its lower side. The cylinder heads are secured to the cylinder flange by heavy stud-bolts, none of which was broken. This figure shows a portion of the cylinder head still in position. The break passed through two of the bolt holes and one of the valve chambers. On the left-hand side the cylinder flange was entirely carried away for that portion of its circumference where it rested against the bedplate, the break starting at two diametrically opposite points of the flange and running around the wall of the cylinder.

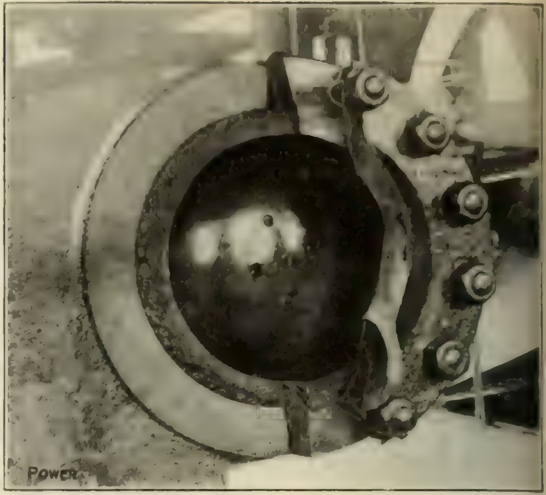


Fig. 2. Damaged Ammonia-Compressor Head

There are no marks on the piston or the cylinder head to indicate that they had been in contact. The line of the break following the fillet of the cylinder flange would seem to indicate that the stress had been thrown upon this portion of the rear flange by something between the front head and the piston sufficient to fill the clearance space of the machine. As the front head was still in place with its valve bonnets when the photographs were taken, this was impossible to verify.

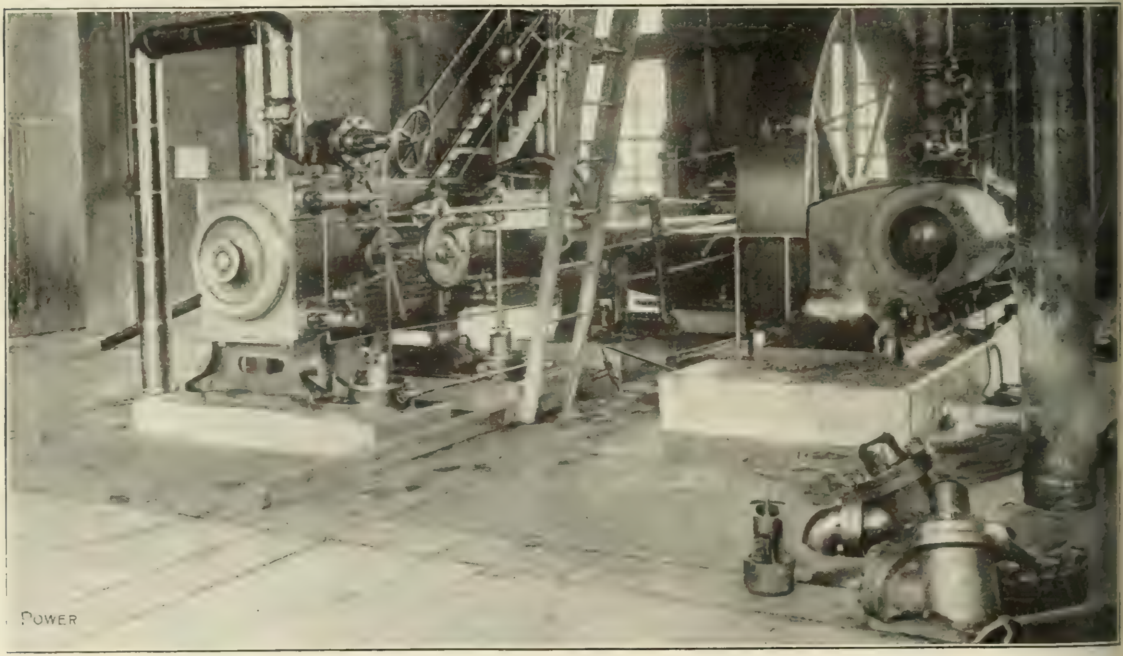


Fig. 1. The Damaged Compressor, Broken Parts in Foreground

How a Fireman Made Good

There was no hotter boiler room in Chicago that August afternoon. The ceiling was low, the boiler load vas heavy and the rest periods were few and far between. But steam had to be kept up and the gage needle pointing o the 150-lb. mark, or the chief engineer would want to now why.

What if it was hot in the boiler room, the refrigerating nachine had to run, and the men sitting at their roll-op desks in the offices above, demanded the comforts of vashed air and of the electric fan.

Tim Donovan was not concerned about these matters, is job was to keep up steam, and there was no time to vorry about the troubles or comforts of others. Perspiring, begrimed with coal dust and wielding a coal scoop ith vim was how the subscription man found Donovan. A short survey of the situation convinced the visitor that he time and place were not conducive to business. As he atched the grilling work of Donovan, his sympathy for he man and his condition sent him away determined to elp him if he could.

Now, Donovan was of a studious nature, which fact he subscription man had learned from the chief; why ot send him a good work on engineering? He did so, ith his compliments, and promptly forgot all about the natter.

Something like two years passed and the subscription nan had forgotten Donovan; in fact, would not have nown him on the street with the grime of the boiler oom removed. As the "sub" man was walking up La Salle St., he received a vigorous thump on his back and big, commanding hand gripped his own.

"Yer th' man I've been lookin' for," shouted Donovan, nconscious of the passing throng. "How are ye, me 'y!" which was emphasized with another thump on the ack.

"Guess you got the wrong man," replied the subscripon man, eyeing Donovan nervously, "I don't know you; never saw you before."

"Not me, me b'y. Come and crook yer elbow, 'tis oime ye had one on me."

"But I don't know you; you have got the wrong man."

"I tell ye I've not. Listen, do ye moind th' day ye ame int' me b'iler room about a year ago, and later n sint me a book on engineerin'? 'Twas th' beginnin' f me success. Before I had nothin' in me dome, now 've ivery thin' in the book, and some more. An', best f all, they can't take it away from me. Do ye see me oyle, son? I can wear me kid gloves an' not neglect e job."

A light began to dawn on the subscription man's mind. hen he knew Donovan and recollected the position he ormerly held. Filled with astonishment at the change e asked Donovan what position he now held and how he ad procured it.

"Man, dear," replied Donovan, "I'm chief out here to ——. All I have to do, compared wid what I us'ter, is sit in me chair and tell th' min what t' do. I'm th' oss, me b'y. I give th' orders, and me days of sweatin' rninst a sit of b'ilers be over. But yer th' b'y what arted me roight wid yer little engineerin' book, and I on't forgit. Now will ye come along an' blow some ıds?"

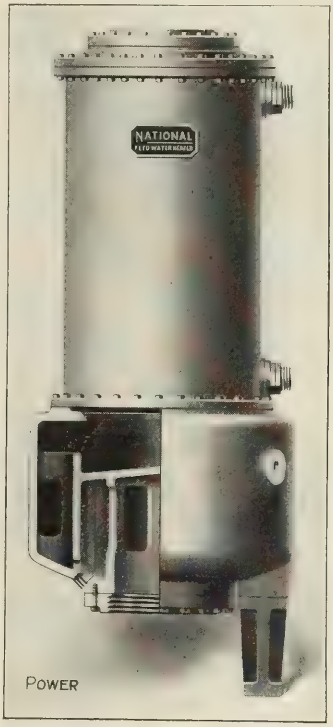
The subscription man later in the day joyously meandered up La Salle St., at peace with Donovan, himself and the world. A little help, and a fireman had fitted himself to occupy a chief engineer's position. He had made good when given the chance and the subscription man got more than the cost of the book out of it, in the satisfaction of knowing that a good turn had helped another to succeed.

National Feed-Water Heater and Oil Separator

One of the recognized advantages of the closed feed-water heater is that the feed water is kept free from the exhaust steam which may contain considerable oil. This type prevents the oil from getting into the boiler even if no separator is used. When installed, the condensed steam continually leaves the heater through the drip pipe, which should always be left wide open.

In some installations this condensed steam can be used to advantage in ice making, for washing, or by returning it to the boiler together with drips from a heating system or other apparatus. But the oil must be gotten rid of, and it is usually easier to take it out of the exhaust steam than to filter it from the condensate.

To facilitate this operation, the National Pipe Bending Co., New Haven, Conn., has made a special closed heater with a separator forming part of it, as illustrated. The separator is placed at the bottom of the heater so that the exhaust steam will impinge upon the baffles, and by change of direction and in passing through the ports shown, will be freed from particles of oil without materially adding to the back pressure on the engine.



Combined Feed-Water Heater

Nations to Be Represented at the Exposition—The following extract from a recent official bulletin on the Panama Pacific Exposition work should be of interest to prospective exhibitors and visitors: "The following foreign nations have accepted the invitation of the United States to participate in the exposition: Argentina, Bolivia, Brazil, Canada, Chile, China, Costa Rica, Cuba, Denmark, Dominican Republic, Ecuador, France, Guatemala, Haiti, the Netherlands, Honduras, Italy, Japan, Liberia, Mexico, Nicaragua, New Zealand, Panama, Persia, Peru, Portugal, Salvador, Spain, Sweden, Turkey, Uruguay, Venezuela. It is now assured that practically all the states of the Union will be represented.

Three-Wire Generator with Revolving Compensator

The adoption of a revolving compensator with one collector ring for obtaining the neutral connection with three-wire operation is embodied in a design recently brought out by the General Electric Co., superseding the familiar separate stationary compensator and two-collector-ring arrangement. The revolving compensator consists of a circular magnetic core upon which are mounted suitable exciting coils, the core with its coils being assembled on a cast bracket bolted directly to the back end of the armature spider, as shown in Fig. 1. The compensator fits under the overhanging end windings of the armature, projecting only a short distance beyond the main winding.

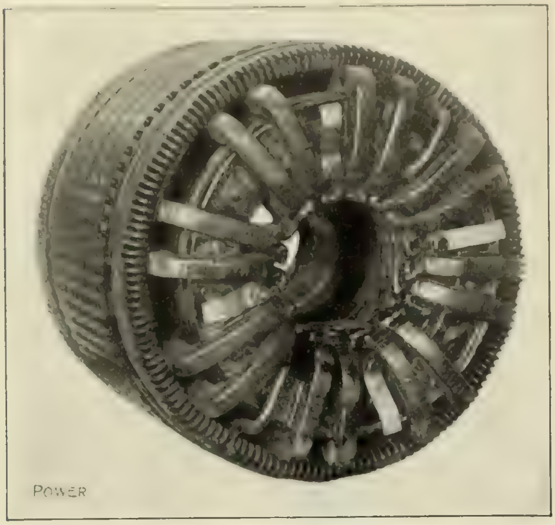


Fig. 1. Armature with Revolving Compensator

The compensator windings are connected to the main armature winding at proper points, and the neutral connection is taken through the armature spider to a single collector ring mounted on the outer end of the commutator shell. This ring may be seen in Fig. 2. The neutral brushes bearing on this ring are supported by and insulated from the main brush-holder studs. The simplicity of this design, self contained with the armature, eliminates floor space taken by the stationary compensator, requires fewer collector rings and brushes and reduces the number of cable leads to the switchboard. These generators are of the commutating pole type.

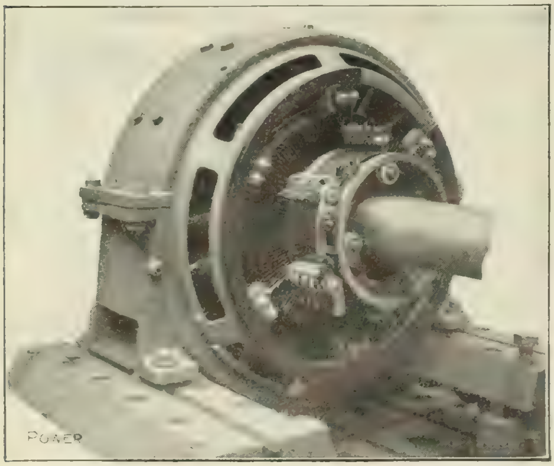


Fig. 2. 250-Volt, Three-Wire Generator, Showing Compensator Ring

⁂

Large Wheeler-Barnard Cooling Tower

The illustration shows a large twin Wheeler-Barnard, forced-draft cooling tower, recently built by the Wheeler Condenser & Engineering Co., Carteret, N. J., for the American Hardware Co., at its New Britain, Conn., plant. The capacity is 132,000 gal. per hour, cooled from 100 to 80 deg. F.

The tower proper terminates just above the platform on which the men are standing, the steel plate work above this being a stack to convey vapors above the roof of the building, and also to provide natural draft for operation in cold weather. The tower is designed with special air inlets which are opened when the fans are not in use and the stack supplies the draft. They consist of counterweighted doors, which when opened, provide a large area for the inlet of air.

Cooling Tower with Forced and Natural Draft

The unit consists of two towers arranged side by side, each 11 ft. 5 in. wide and 18 ft. 3 in. long, erected over a reservoir which also serves as a foundation for both towers. The chimney is 18 ft. 3 in. square and the height from the base of the tower to the top of the stack is 70 ft. Forced draft is supplied by four 108-in. fans.

Refrigeration Plant Troubles and Remedies

By William S. Luckenbach

YNOPSIS—The article is replete with solid, practical ints and instructions. It tells what indicates weak amonia; how to calculate the amount of fresh ammonia quired; why ice gets dirty; cleanliness of ice as influ-nced by carelessness in pulling the ice; cold losses inuced by irregular pulling of the ice; filling of cans and ilure to keep brine tank properly covered.

⁂

Proper Arrangement of Cooling Coils

Coils in the brine tank of all machines of over three · four tons capacity should be in sections of from four to x coils per section, with a division in the center of the ·ction. This is better than one continuous header, for ıe coils furthest from the expansion valve will receive ıore than their share unless there is a valve on each coil › govern the supply. To nicely regulate the flow of the ıs requires considerable skill and judgment, and at best ıe result is not satisfactory because the quantity of gas :quired for a few coils is so small that it is difficult to ·t the valves properly.

On the other hand, if all the sections are connected › one main header and are regulated with one expanıon valve, the distribution of the expanded gas will be ıirly equal over the entire tank. Each section, however. hould have a controlling valve, and each coil, at both op and bottom, should have a valve in case of accident o that any coil or section could be cut out without ıterfering with the plant. There is no set rule as to he proper amount of liquid to feed or allow to pass hrough the expansion valve for any number of coils.

We will assume that the liquid ammonia on the highressure side is, say, 99 per cent., pure and is at norıal pressure regardless of the style of machine. Open he expansion valve slowly and note the frost on the ipes. If they frost nicely, open the valve a little more t intervals, until the frost gets moist, then close slightly s you have reached the maximum of expansion under hat pressure and temperature. As the proper capacity lepends largely on the purity of the liquid ammonia, it s of the greatest importance to test it occasionally. The nethod of testing the ammonia for purity has been decribed in a former article.*

If it usually is pure and the test shows moisture after vaporation, it may be due to the rectifier, or to allowng the rich liquor in the generator to get too high and ·ause a partial boil-over in the generator. Should the rost beyond the expansion valve, become moist or drop ›ff, it is an indication that the liquor level in the generıtor was, or is, too high. If still too high, stop the amnonia pump until the proper level is restored. When he freezing tank is above the absorber (as it should be) ınd the pressure in the absorber is lowered, the accumuated ammonia in the brine tank coils will flow to the ıbsorber by gravity. If, however, the absorber is on a evel with the tank, then create a vacuum in the absorber for a few minutes by closing the weak-liquor valve and start the ammonia pump. After the liquor has been drawn into the absorber, which will be indicated by the rise of the liquor in the gage-glass, open the weak-liquor valve again and run the pump to suit the proper level in the generator. As the temperature of the brine will rise during this time, the machine will require special attention until normal conditions have been restored.

Loss of Liquor

After a machine has been in operation for some time, the liquor in both the generator and the absorber may fall, perhaps without any apparent cause. In a new plant it may be due to an insufficient original charge, providing the rich liquor remains the same in density; but, if after restoring the proper level it falls again and the strength is also less, there is something wrong. First, the cooling water of all the coils and the brine must be tested with litmus paper or Nessler's solution† to determine if there is any leakage of ammonia. If there is no leakage, the loss may be due to some of the liquor being pocketed in a low place in the piping system or in the expansion coils in the brine tank, when that tank is so located that a gravity flow to the absorber cannot be established. In that case, the liquor must be drawn into the absorber by a vacuum. If this should not normally restore the level, air may have been trapped in the top condensing and cooling coils and found its way slowly into the absorber, where it has been burnt off at the purge cock and some of the air space filled with liquor.

Making Up Ammonia Losses

In absorption machines, aqua ammonia should always be kept at the standard density of 26 deg. Baumé; 27 or 28 deg. is preferable, providing the ammonia pump is in condition to handle it. This is especially advantageous when the generator is using exhaust steam because it requires less heat to liberate the necessary percentage of gas, and the weaker the rich liquor, the higher the temperature of steam needed to liberate the same percentage of gas. We will now assume that the rich liquor has weakened to 24 deg. Baumé and that we wish to increase its density to the standard, 26 deg., by adding liquid ammonia. The amount to be added may be found in the percentage table of strength of ammonia liquors. Aqua ammonia at 26 deg. contains about 28 per cent. of pure ammonia and at 24 deg., 24 per cent.; the loss is 4 per cent. of pure ammonia.

Suppose that the original charge was 10,000 lb. at 26 deg., 28 per cent., or 2800 lb. is pure ammonia. Then 4 per cent. of this quantity, 112 lb., will again bring the whole charge up to 26 deg. The simplest method of introducing it is to connect directly to the brine and take up heat. Then it is only necessary to see that it is not admitted to the coils faster than the weak liquor flowing into the absorber can absorb it. Again, suppose we wish to use aqua ammonia to increase the strength, but find that this cannot be done until some of the weaker liquor in the system has been withdrawn. We also want to know about how many drums to order without guessing, so as not to have a drum or two about the place for which we have no use. Take the same example of 10,000 pounds originally with 1 per cent. loss of pure ammonia. In distillation, it is difficult to get below 12 deg. Baumé, or 2 per cent. additional loss on the whole amount, but as only a small part of the 10,000 lb. is distilled, the actual loss would be approximately 1½ per cent. of the 2800 lb., or 126 lb., and as aqua at 26 deg. contains about 28 per cent. of ammonia, the balance, 72 per cent., would be water. Thus we need 126 × 0.28 = 35.3 lb. of new ammonia.

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*"Power," Mar. 24, p. 411.

†See "Power," Mar. 31, p. 450

The quickest way to distill the liquor to 12 deg. is: Stop the pump and close the poor-liquor valve, leaving the gas and the steam valves open, as well as the expansion valve. This will reduce the pressure gradually in the condensing coils. When the density has been reduced to about 12 deg., close the gas and the steam valves, draw the required amount at the bottom of the generator and pump strong liquor to replace the weak. Now open the steam valve, but do not open the gas or poor-liquor valves until the generator pressure is about equal to the poor-liquor pressure due to its head or height above the liquid in generator, otherwise the generator might be flooded. Next open the valves slowly; the machine, however, will need careful attention until the pressure and the liquid levels are normal.

Purity of Ice

Artificial ice is made either from distilled or ordinary drinking water, usually termed raw water, but when steam is the prime mover, distilled water should be used because of its purity. Where raw water is employed, the first requisite is pure water, or such as can be made so by chemical treatment. Furthermore, air agitation is essential, either by the can or the plate system, to avoid white or opaque ice. The can should have a capacity of not less than 300 lb., thus avoiding a multiplicity of connection from the main air pipe. This pipe should be close to the return gas pipe in order to reduce the air temperature at least as low as that of the water in the cans or tank. Distilled-water can ice should not be frozen at a lower temperature than, say, —10 or —12 deg. F., because the ice forms more rapidly when directly in contact with the can and may give an opaque appearance on the outside of the block.

Opaque ice from distilled water is frequently due to carelessly handling the can filler when the can is full. Withdrawing the filler should be done with as little agitation as possible. The causes tending to make excessive core and dirty bottoms are numerous, such as impurities in the water carried over with the steam, especially if the water in the boiler gets too high; insufficient reboiling of the distilled water, fluctuating level in the distilled water tank or forecooler, thus alternately exposing and covering the coils or pipes, and invariably washing off some dirt. A dirty filter is another cause. One common cause that is frequently overlooked or underestimated is that due to dirt accumulation on the top of the freezing tank. The cleats on which the bath lids rest must be clean; dirt must not drop into the cans. The top of the lids should be free from dirt also, because dragging the bottom of one lid over the top of another is bound to carry dirt with it and deposit it in the can. The engineer will usually investigate every place but the dirty lids. Put a good mat at every entrance to the freezing tank, and over each entrance place the sign, in large letters, "*Wipe Your Feet.*"

Both the raw and the distilled water should be tested occasionally for purity. This can easily be determined by using nitrate of silver or chloride of barium. To find which is preferable, especially in distilled water, draw two glasses of water from the feed to the steam boiler, put two drops of nitrate in one glass and two drops of chloride in the other. The chemical showing the greatest precipitation should be used, and if the water in the tank or the cans prove to be pure, there is no need to go further. If, however, the distilled water is impure, a second test should be made from the pipe leading from the distilled water tank to the filter. If this is pure, it is plain that the fault is in the filter. On the other hand, if the water shows a precipitate, the fault is either in the distilled-water tank, the generator or the steam boiler, and the test should be continued.

In case one can taste or smell ammonia in the water, about the same method would apply. This trouble may be in any part having return gas pipes passing through it, or it may be a leaking steam pipe or coil in the generator. After having determined the origin of the trouble, cut one coil or tube out at a time until the defective one is reached, then cut that out of service entirely. Locating this may take some time, and it may be advisable to use raw water instead of ammonia-impregnated, distilled water. Should the defect be in one of the generator tubes or coils, it may be temporarily necessary to either use a higher strength aqua ammonia or a higher steam temperature to liberate the percentage of gas for normal capacity because of the loss of one tube or coil.

Pulling Ice and Filling

It is essential that the stated number of cans be drawn every hour. If more are pulled at any time, the economy of the plant is disturbed, especially where distilled water is used, as the water will be warmer if the extra cans are filled. If they are not filled, the brine will be lower on the outside of the other cans in the bath and, of course, decrease the output to that extent. The surface of the brine, where the extra cans have been withdrawn and the lids left off, will also be exposed to the temperature of the atmosphere, which is usually about 65 or 70 deg. warmer than the brine. This practice is inexcusable.

The exposure of the brine to the surrounding summer heat should never be longer than necessary for the withdrawal of a few cans or a plate block at any one time, and all hot air from the engine or the boiler room likely to increase the temperature on top of the bath must be prevented from getting in the freezing room.

If there is likely to be a shortage of distilled water, start filling as soon as the water runs at the overflow of the tank, regardless of whether it is just on the hour. Have a few extra cans, so that the cans from which the ice has been dumped can be turned down and well drained, thus preventing bad butts or second-quality ice.

Many of these suggestions may seem of little consequence, but in the aggregate, the loss can be readily seen and computed by any progressive engineer and be appreciated by the owner. Proper attention to all these matters requires but little of the engineer's time after a proper system of daily inspection has been established.

Editorials

Helping the Helper

By the very meaning of the words "assistant" and "helper" the engineer regards his subordinates as for the purpose of assisting and helping him. How often does he think that there is any return obligation on his part? Many engineers are humanly interested in those working under them, and thanks be to such men! In times gone they have done much to raise up worthy successors to fill their places and there is still a goodly number doing it, some if for no other reason than that they ought to do it because someone once did it for them. A few—we hope they are exceedingly scarce—are so small-minded that they fancy it is prejudicial to their own good to teach helpers too much, lest they displace their teachers too soon.

No, we like to feel that, if there is a growing disposition to neglect the instruction and counsel of his assistants, the engineer is doing it from force of circumstances—not deliberately. In small plants, and all plants were small in the old days compared to the present average ones, there was time to give some thought to the welfare of the young chaps who were just learning the gentle art of plant operation. Today, the chief usually is a very busy man; his mind is occupied with many large propositions; he is keener of his responsibility to a critical management, and he has little leisure to consider the needs of those under him. They must be capable assistants or his natural tendency is to look for others rather than train them to the proficiency he requires.

This is a serious condition of affairs if we did but realize it. Somewhere, these beginners must get their education in power-plant practice. Schools have come into existence to do a great deal of this work and are filling an important economic need. Still, not all young men have the time or the funds to go to school. They must get to work for their own support, and often the support of others dependent upon them. You older men, have you ever thought what a severe handicap these young men have placed upon them? Is it not your habit to comment, if at all, on how much greater are the advantages enjoyed by the youth of today compared with what you had? Where there are many who do enjoy advantages, there are some who do not. They can see only the much greater amount of information they must have to handle the more complicated equipment and to handle it in keeping with the more exacting standards now imposed. Worst of all, they are expected to have this knowledge when they start and are in fear of discharge the moment their shortcomings are discovered.

Here is a thought: Just suppose you give these men who are on your staff somewhat the same consideration you do the plant equipment under your charge. Treat them at least as well. You find a certain piece of apparatus not up to its proper performance. What do you do, scrap it? Hardly; your employer would probably object if you wanted to. So you first examine it to see if it cannot be improved. Possibly it is only a little out of adjustment, or it is worn, or even broken in some minor part, when you examine into it. A little time spent in renewing defective parts or overhauling, with little or no expense, and it goes on doing as good or better work than before.

Now, how about the oiler or fireman who is not doing the kind of work you expect? If he has not got it in him to be a better workman, you do him a service in discharging him, with the advice to get into some line for which he is better fitted. But be sure you give him a chance if he deserves it. Show him why this or that way he has of doing something is not right. Then teach him to do the right way himself. Incidentally, you will get a loyalty in that man which money cannot buy.

Another thing, do not be unreasonably harsh with your men over their faults. Cursing them is just as foolish as banging a balky pump with a hammer, and does about as much good.

You can carry this analogy between your men and your machinery as far as you like. Really they are both machinery in a way, and how much more important it is to be patient with human machinery, for that can manifest appreciation in return. If you are not appealed to by higher motives, there are plenty of selfish reasons for your helping the helper.

Should Heating Boilers Be Insured?

However much our respect for the destructive possibilities potential in a boiler carrying high-pressure steam, we are inclined to underestimate such ability in a low-pressure heating boiler. The latter looks innocent enough. It would seem ridiculous to think of requiring licenses to operate heating boilers and, it is true that, in proportion to their number, relatively few of them so far forget their good manners as to do much serious damage.

Nevertheless, when we read of an occasional heating-boiler outbreak, such as that described on page 622, it may well cause us to pause and consider. Fortunately, in this instance, no lives were lost. The building was a church and empty at the time, but, had the explosion occurred during a service, the loss of life might have been appalling. This consideration of the much greater number of people likely to be within the range of harm from a heating boiler as compared with a power boiler emphasizes the importance of giving them an equivalent amount of attention to prevent disastrous mishaps.

This Des Moines accident was not the only recent one of the kind. Within a few months, at least three serious heating-boiler explosions have occurred. The further quotation in the present article from the British Board of Trade report on a similar explosion shows how general is the experience and how especially needful it is that interest to the point of action be aroused for some-there to be done to reduce the menace accompanying an unintelligent handling of heating plants.

We hold no brief for the insurance fraternity, but the good work it has done in the direction of diminishing power-boiler accidents naturally suggests its probable usefulness in the broader field. Again, to cite the explosion mentioned in this issue, there was a ten- to twelve-thousand-dollar property loss uncovered by insurance. Few power-boiler explosions involve a larger amount.

Laws of the right kind would doubtless be a help, but legislation is a slower remedy than insurance on account of the delays in getting it established. However, no one agency should be relied on entirely. Compulsory inspections would be the best protection. Next to these come those that are furnished by the insurance companies wherever they issue policies. Much can, therefore, be accomplished when the public is convinced of the occasion to insure heating boilers and finally, and most immediate in their effects, once their importance is recognized, are the precautions which individual owners could and should take for their own good. Several of these are noted in the British Board of Trade report and deserve repetition here:

Provide safety valves.

Hire competent attendants.

Post in a conspicuous place printed instructions for the care and use of the apparatus.

See that these instructions are understood and followed.

Have periodical inspections by qualified experts.

Install reliable equipment.

Practically all of these precautions will be enforced when insurance is taken out on the plant, and the owner will have the satisfaction of knowing that if any loss does follow he will be recompensed financially.

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Inside Inspection

It is second nature for every engineer, as soon as he comes on duty, to inspect the machinery under his care. He feels the bearings; sees that all the oil cups are full and that the oil is flowing freely; he notes that the needles on the switchboard instruments and the steam-pressure gage are pointing to their proper figures. Automatically and as a matter of habit, he repeats these observations at fairly regular intervals throughout his watch.

There are some engineers who consider that this daily round of routine inspection is the extent of their job. Fortunately for all concerned, their number is daily diminishing. They regard such work as keying up of loose brasses or adjusting governor springs as necessary but incidental. As for removing cylinder heads, opening valve chests or lifting out main bearings at opportune moments, to know the true state of an engine, the number of reasons for not doing these things which an indifferent engineer can give is astonishing. The common ones are: "Too busy"; "What's the use?"; "She's always run all right"; "This engine has never cost a cent for repairs so far."

This "let-well-enough-alone" sentiment is now so common in almost every line of business as to scarcely excite comment, even from those most interested. In the engine room, however, it must be banished. The failure to periodically look into and overhaul every piece of mechanism and piping in a plant sooner or later brings disaster. Breakdowns, interruptions in service, increased operating costs—these are the dread of all conscientious engineers, yet all of them can be practically eliminated by a thorough search for concealed defects.

No machinery can be expected to keep up to its original performance after its working parts have begun to wear, but the wear on essential parts, with the consequent loss of efficiency, can always be kept within reasonable limits and generally made a negligible quantity by systematic inspection to discover and remove any source of wear before it can do harm. As an instance, consider the worn and leaky piston ring. It may be responsible for the loss of only one-twentieth of a pound of steam per stroke, yet in the average engine doing its hundred revolutions per minute, ten hours a day, this represents a daily waste of six thousand pounds of steam.

After a wide-awake, enterprising engineer has entered a plant to take up the burden laid down by an indifferent engineer, it is the expected that always happens. The operating costs gradually decrease as one by one the various units are inspected, their particular defects discovered and the proper remedies applied.

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Tuning Up the Refrigerating Plant

Now, as the time approaches to put the refrigerating plants into commission which have been idle during the winter, the article on "Ammonia Fittings," in another part of this issue, is timely. The reasons for many of the piping troubles due to leaks will be apparent when the various types of joints are understood. To those of long experience with refrigerating equipment, there may be little in the article referred to that is unfamiliar, but others more accustomed to the fittings common to steam and water lines will find many helpful points in this article. Modifications in present systems may be suggested by a better appreciation of the peculiarities of the usual forms of ammonia fittings or of the variety of forms that is available, some offering possibly better substitutes for those now in use.

We also commend to the attention of all concerned the "Accident to Ammonia Compressor" and especially "Refrigeration-Plant Troubles and Remedies," the other two refrigeration articles in this number, and for the benefit of any who may have missed them, the following recent ones which may prove of assistance while getting in shape for the summer service:

"Practical Refrigeration-Plant Suggestions," Mar. 24, 1914.

"Testing for Ammonia in Brine," Mar. 31, 1914.

"Starting and Stopping an Absorption Refrigeration Plant," Apr. 21, 1914.

⁂

A German statistician states that the rapidly increased used of electricity over gas in several German cities in the last ten years is, in some instances, two to threefold. It is probable that, as in our large cities, the energy and tenacity of the lighting and power interests are responsible for the decreased use of gas. While gas is at present holding its own in the smaller communities, it is contended that it is mainly because the small field is held in altogether too much contempt by the electric-lighting interests.

Correspondence

Operating Condenser without Hotwell Pump

The article on this subject, on page 75 of the Jan. 13 issue, was interesting to me, as I have from time to time had to run a condenser with the hydraulic air pump doing all the work.

The turbine is usually running at full load, about 1150 kv.-a. We found that with the extractor pump shut down, we could still run with 94 per cent. vacuum (instead of the usual 96 per cent.), corresponding to an output of 1050 kv.-a., for about 4¼ hr., when the vacuum would fall rather quickly. As the vapor and air pipe to the air pump is taken from about halfway up the condenser side, the latter was filled so far with condensed steam.

When the vacuum, and consequently the load, dropped, the only way to restore it was to shut down the steam side, drain the condenser and start over again, the whole operation taking about half an hour. As the machine was on a large alternating system, the loss of load was not serious. Considering the largely reduced tube surface, 94 per cent. seems a remarkably high vacuum to hold. It is difficult to account for the sudden periodic fall. Obviously, the air pump must have been dealing with condensate as well as air and vapor for a long time before it failed. The theory that the condenser is much too big for its work will not hold, each set being complete and modern.

R. Dilworth Harrison.

Middlesbrough, Eng.

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Where Should the Oil Separator Be Located?

Answering G. S. Sprague as to the above query, I have had similar trouble, and will explain how I overcame it.

My oil separator was located practically in the same place as Mr. Sprague's, but where he shows a drain to the sewer that he closes when running, I installed a low-pressure trap with a swing check valve between it and the exhaust pipe. The line is open all the time and water and oil cannot collect in the bottom of the horizontal run at light loads and then be thrown over too fast for the separator to take care of when the load increases.

I also tapped the drain connected to the separator a size larger and connected the pipe to a tee in the trap line between the trap and the check. Since making these changes, I have had no trouble with oil in my returns; before, I had plenty.

There is less waste by using a trap than to pipe direct to the sewer or to put in a valve and just crack it enough to let the water out, as I have seen done in many plants. When this is done the opening is not enough, when the back pressure is light, to let the water and oil out, or if it is opened too much a great amount of steam is wasted. The trap also acts to a certain extent as a receiver, and the separator does not become flooded as it otherwise would when first starting or upon starting another engine or pump connected to the same exhaust line.

A. O. White.

Genoa, Neb.

[Since publishing two letters in reply, there have been several others received. All agree in general terms that the location is not responsible for the failure. This one describes a similar difficulty which has been overcome and is therefore given preference.—Editor.]

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Heated Air for Steam-Boiler Furnaces

The letter on this subject, by Mr. Odell, published in the Dec. 30 issue, has recently come to my attention. Although the letter is old, it raises questions, the discussion of which should prove interesting. Mr. Odell asked why heated air is not more generally used, when such economical results are possible as proved by the tests financed by an association of manufacturers. The present limitations to the use of heated air are due to the characteristics of the fuel—that is, the plan has failed because with average coals it has caused excessive formation of clinker.

Providing the ash contains substances which will fuse, clinkers will form when the ash is subjected to a temperature higher than its fusing point. Fortunately, the surface of the fire is usually the hottest part, and from there to the grate the temperature gradually decreases, slowly at first and then more quickly as a region is reached where much of the combustible matter has been burned out of the coal and the cooling action of the air coming up through the grates is not offset by the intensity of combustion. Thus as more and more of the ash particles come in contact they are working down into a cooler part of the fire, and unless they melt at a comparatively low temperature they will not melt and run over the grate, even though the melting point of the ash is less than the temperature of the upper part of the fire.

In numerous boiler tests it has been found that when the melting point of ash falls much below 2400 deg. F., clinkers are formed, while coals having ash melting at 2600 or 2700 deg. F. give little trouble under the same boiler rating and draft conditions.

If the air supply to the fire were heated 250 deg.—that is, if it went into the ashpit at a temperature of about 300 deg. F.—the temperature of the fire would be about 250 deg. higher all the way through and the coal having ash which melts at 2400 deg. F. would be in the same position as the one in which the ash fuses between 2100 + 220 deg. F. with cold air supply. To get a coal which would give even tolerable results, it would be necessary to obtain one where the ash would not melt below 2650 deg. F. There are only a few regions which can supply a coal of this character and these must be carefully prepared at the mine and are expensive.

On the other hand, the system would effect large economies, for the efficiency of the boiler would be increased 3½ and 4 per cent. for each hundred degrees of heating of the air supply; this would mean a coal saving of 5 to 5½ per cent., provided this heat were taken from some source of waste heat. In this way the air heater would act like an economizer and reduce the temperature of the gases, so that a fan or a very tall stack would be required to maintain the draft. Where conditions warrant the complication and expense, an economizer will give the same operating efficiency with less incidental troubles and get the benefit of this heat which otherwise would have to be used in the air heater. In other words, if you have an economizer, there isn't heat enough left to operate an air heater, and in a choice between the two the advantages are all with the economizer.

On shipboard, where the weight of an economizer would be prohibitive, air heaters have been used quite extensively, as in the Howden, and the Ellis and Eaves systems, the chief difference being that Howden's system uses a forced-draft fan and closed ashpit, sending the air to be heated around the tubes of the air heater, while the Ellis and Eaves system uses an induced-draft fan and draws the air to be heated through the tubes. In neither does the air supply attain a very high temperature.

With oil-burning boilers, where there is no clinkering to be considered, this is an ideal arrangement, as it produces a short, hot flame and aids in obtaining smokeless combustion with a minimum quantity of air. Heated air injected into a locomotive firebox, as in the Parsons system, has been used with good effect both in improving smokeless operation and economy, provided the air was hot enough and the right quantity was supplied. I hope that this will explain to Mr. Odell some of the difficulties incidental to air heating for boilers.

H. D. Fisher.

Newton Highlands, Mass.

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Settling Chamber for Filter Coke

Mr. Fenwick, in a letter under this title in the Apr. 7 issue, shows how the small pieces of coke used in some of the open-type feed-water heaters may be prevented from going into the feed pump.

At one time I had considerable trouble with an open heater. The floor of the coke chamber is made of iron plates having a large number of small holes through which the water passes, but it retains the coke, and the pump suction is taken from below this plate. The greatest trouble was just after putting in new coke. The method we used to prevent it was to spread a layer of burlap, such as comes around bales of waste, over the iron plates. This will allow the water to pass through, but will prevent anything but the finest of the coke from passing. This burlap will also catch much of the scale-forming matter which passes through the coke. Usually, a new piece is used each time the filter is cleaned.

The idea presented by Mr. Fenwick is not entirely satisfactory in that the coke is light and will not readily settle into the trap; it would likely be carried by with the water to the pump. If a strainer of small mesh were inserted in the joint just above the tee, the coke would be stopped, but a strainer located at this point would soon clog up, although it probably could be flushed off by opening the valve at the bottom of the trap leg.

In addition to the burlap on the bottom of the coke chamber, we also found it advisable to place a layer of burlap over the coke with a few bricks piled on top to hold the coke down. The reason was that it would float and work into such position that it interfered with the ball float controlling the feed-water inlet. We were also advised that hay was much better to use in the heater in place of coke as the hay would hold back more of the scale-forming matter which was precipitated in the heater, and some of which would pass over with the water to the boilers. We only used this once. It would not last long, and gave too much trouble from breaking up and passing through the heater to the pump.

J. C. Hawkins.

Hyattsville, Md.

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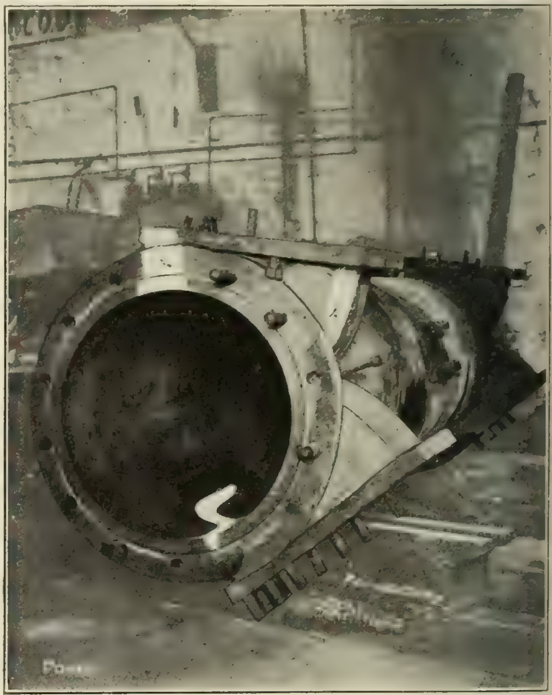
Large Engine Cylinder Welded

The illustration shows a steamboat-engine cylinder 24 in. by 8 ft. that was damaged by a "dose" of water. The cylinder was cracked in two places for 18 in. in the direction of its length, and big lugs were broken out of the steam chest. A new cylinder was telegraphed for. The reply was that the builders who made this cylinder were out of business, and had been for seven years. For making a new cylinder a local iron works would charge $720, and it would be at least two weeks before the boat could be put back into service.



Where the Engine Cylinder Was Welded

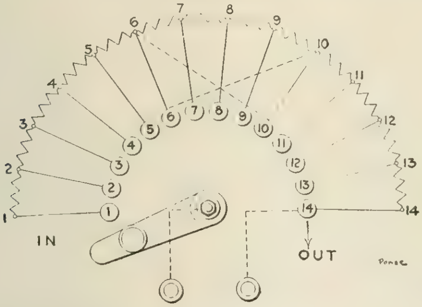
As a last resort, a welding concern was given the job of patching and welding the cylinder. The job was done in 36 hours for $66, after which the boat steamed up the Mississippi River, and has been in constant service for the past three months.

J. W. Dickson.

Memphis, Tenn.

Field Rheostat Trouble

Engineers accustomed to keeping a constant check on the existing condition of their equipment so as to be able to promptly trace the cause of irregularities that may occur, mark the positions of their generator-field rheostats both for cold field and for hot field. The advantage of this is illustrated by the following:



Contact Points Connected to Wrong Resistances

An old rheostat that had been in use for years was taken apart to fix an open-circuited connection. As several of the dial leads proved to be in bad condition, they were renewed also and reconnected. On reinstalling the box and placing the handle bar upon a marked dial plate corresponding to no-load normal voltage, the machine promptly built up to normal voltage and everything was assumed to be all right. After the machine had heated under load, however, it was found that upon placing the rheostat in the position marked for this condition, the machine undercompounded considerably.

The engineer naturally suspected a fault in the rheostat because that was the only thing that had been disturbed. On removing the rheostat panel and checking the connections, he found leads 6 and 10 interchanged, as indicated by the dotted lines in the sketch. The interchange happened to involve the No. 10 plate that held the hot field mark, with the result that advancement from plate 9 to plate 10 cut in four resistance sections instead of cutting out one section. With two machines in parallel, such a condition might have caused trouble, but the engineer discovered it in time.

J. A. Horton.

Schenectady, N. Y.

Why This Ice Plant's Capacity Was Low

Recently a new ice plant which had been in operation only a few weeks began to drop off in capacity, and as matters got worse, an engineer was called in to locate the trouble. He found that the freezing tank coils were heavily coated with salt. It developed that when the brine was made, before the plant was put in operation, the erecting engineer had used so much salt that after the water had taken up all it could hold in solution, the balance was deposited on the coils and crystallized there, forming an insulation between the ammonia in the pipes and the brine.

It appeared that after the brine was brought to its proper density, there were several bags of salt left over; the erecting man dumped them into the freezing tank rather than bother with shipping the salt back to the factory.

The brine was drawn out of the tank and the coils and tank cleaned, after which the brine was put back and enough fresh water added to bring it down to its proper density.

Each coil was fitted with drain connections at the bottom which passed through stuffing-boxes at the end of the tank. The drain valves on each coil were opened and 32 gal. of ice-machine oil drawn off. This showed that the oil trap on the discharge line between the compressors and the condensers were being neglected and that too much ammonia oil was used.

After the plant was put in operation the second time there was no further trouble, and the plant developed its capacity.

Jacksonville, Fla.

C. T. Baker.

Ignition-Trouble Remedy

In a producer-gas power plant, which came within the writer's observation, considerable trouble was experienced with the engines missing. An investigation showed the cause to be in the make-and-break ignition system, the heat from the spark periodically welding the nickel-composition electrodes together; they would stick for a time, causing the engine to miss, then break loose again. These nickel composition electrodes were replaced with cast-iron ones and there was no further trouble from this source. The arcing surfaces of the cast-iron electrodes seemed to wear smoothly, not having the tendency to pit and corrode, as in the case of the other electrodes.

C. J. Barton.

Chicago, Ill.

Oil in Boilers

This is an old subject, but it frequently comes up in boiler-room practice. No set of rules can cover all cases and long experience is most essential in correctly judging how to remedy troubles due to the presence of oil.

After years of experience with this problem in our plant, we seem to have arrived at a fairly satisfactory solution of it. The condition was bad as the boilers were so caked with oil and grease impurities that a dozen tubes had to be replaced before the boilers could be put in service. All possible means were adopted to prevent the oil from getting in, but still some got into the boilers. A compound cylinder oil had been used which contained a high percentage of animal matter. The oil seemed to emulsify in the water and cause the foreign matter to adhere to it, the entire mass settling to and depositing on the shell, where it would bake, forming scale which prevented the water from making good contact with the heated plates. The scale was not hard and could be easily shoveled out when the boilers were opened.

It was decided to make a change in the oil and use a pure mineral oil which would not cause foreign particles to adhere to it and would, therefore, stay on top of the water. Surface blowoff pipes were provided; they were used daily and reduced the accumulation materially. In opening the boilers it was found that while there was practically no deposit in the bottom, there was a considerable coating of oil in the zone of the water level. While perhaps not dangerous, this condition was still unsatisfactory as the accumulation was difficult to get off, as well as forming an insulation from the heat of the gases.

The boilers are of the return-tubular type, in which the gases make a pass over the top of the shell. As a last resort, soda ash was fed weekly into the boilers, with a daily use of the surface cock and bottom blowoffs. The boilers are now 11 years old and it so happens that the same inspector has been inspecting them for the major part of that time. He reports that they are now in better condition than ever.

Edward T. Binns.

Philadelphia, Penn.

Experience with Gas Burners

In changing from coal to gas fuel the Oklahoma Gas & Electric Co. encountered several obstacles which taxed the ingenuity of the engineers.

The boilers were of the ordinary water-tube type and were unchanged except for the firebox being remodeled for gas, and a type of gas burner was used, as shown in Fig. 1. It consisted of a pipe with a bell-shaped mouth, the end having adjustable shutters for air regulation. The gas was admitted to the burner through a ring situated around the burner tube with circumferential openings into it. By means of the air shutters and the gas valve any desired proportions of air and gas could be obtained. The burners were fixed in the furnace wall, as in Fig. 2.

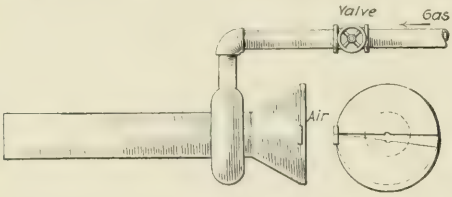


FIG 1

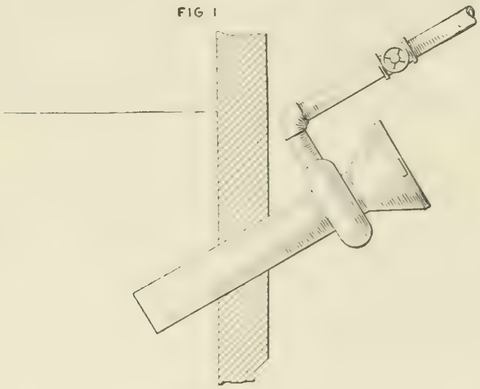


FIG 2

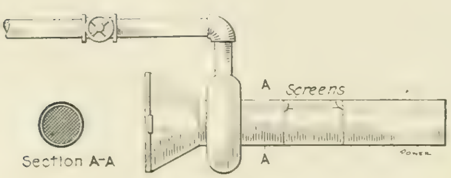


FIG 3

Gas Burner before and after Alterations

After installing the burners and putting the boilers in operation, they worked satisfactorily for a time and then, apparently without cause, there occurred cyclic explosions inside the firebox, causing severe vibrations of the boiler and rendering operation unsafe. Careful adjustments of the feed and remodeling the baffle walls and inside arrangements of the firebox did not remedy matters.

Various reasons were advanced for the cause of the explosions, the most plausible being that the air and gas were not mixed intimately in the burner tube so as to burn near the end of the burner, but were drawn back into the firebox before mixing and then ignited in such a large volume as to cause the vibration, this effect causing a partial vacuum at the burner end, thus drawing in another charge of fuel which in turn exploded.

In line with this reasoning, two wire screens were fastened in the tube near the furnace end, the first being coarser than the second; see Fig. 3. The screens seemed to effect a more uniform mixture of the air and the gas, and the explosions ceased. But that which was not anticipated, occurred as a secondary result—there was a diminution of 20 per cent. in the cubic feet of gas used per kilowatt-hour.

L. W. W. Morrow.

Norman, Okla.

Carborundum vs. Emery Cloth

In the Jan. 6 issue under "Inquiries of General Interest" and in the "Correspondence" of the Feb. 24 issue, reference is made to the danger of using emery cloth around a dynamo. Emery, most assuredly, is not fit to use, but I have found that carborundum cloth may be used without the attendant danger of loosened particles lodging between the bars and causing short-circuits, as emery will do. I have used it on commutators and brushes and have never had any but the best results.

After using the carborundum, however, it is best to blow off the commutator and brushes with compressed air or a bellows to prevent any particles from getting into the journals and cutting.

W. W. Pettibone.

Ludlow, Ky.

Value of Laboratory Coal Testing

Some time ago the plant shut down all night for lack of steam. The superintendent blamed the shutdown to poor coal. The coal was sampled and tested by the laboratory, and as the results were comparable with coal that had given satisfactory results, it was pronounced all right.

The tests were made on 50 lb. of finely ground and quartered coal taken from each car. The proximate analysis included moisture, volatile combustible material, fixed carbon and ash. The moisture and ash are quantitative determinations, but the other two are empirical.

The superintendent, a man of 25 years' experience in power-plant work, maintained that the laboratory tests were worthless, they told nothing. The chief chemist, an experienced man, saw that the tests were carried out in the most approved manner.

The trouble in this case was in burning the coal. It was impossible to hold the load. How could the chemist tell how the coal was going to burn from the above tests?

These tests do not satisfy power-plant operators because they do not tell enough. Much ill feeling often arises between the power plant and the laboratory because too much is expected of these tests. They are inadequate, which shows the need of more practical methods of testing.

It would seem highly desirable to have an apparatus which could be placed in the power house to burn a sample from each carload under conditions closely resembling the actual situation under the boiler which would record the British thermal units per pound. The ash could be weighed, which would give the percentage. The burning of a 40- or 50-lb. sample of coal from each carload would give opportunity of watching the combustion, noting the coking of the coal and the physical properties of the ash.

I would like to hear what other power-plant operators and chemists think of the value of the laboratory tests of coal.

Chicago, Ill. C. J. Barton.

Bushing a Piston-Rod Gland

Referring to the article on page 440 of the Mar. 31 issue, "Bushing a Piston-Rod Gland," I have had a like experience.

On a Corliss engine, which has been in use for about 18 years, the rod was so badly worn that it was almost impossible to hold the packing in place. I had the gland bored out similar to the illustration just mentioned, but instead of using an iron or brass bushing, I obtained a good grade of babbitt to bush it. I could get a very close fit without fear of scoring the rod.

Previous to bushing it was necessary to put in new packing about every week. I sometimes had to keep the packing so tight that the rod would get hot, and at one time one of the gland bolts broke. The present packing has been running about six weeks and shows no signs of blowing; I keep the nuts just tight enough not to come off.

Knoxville, Iowa. Roy L. Peterson.

Cause of Corrosion of Pump Rod

I noticed, in the Mar. 17 issue, R. G. Lovell's inquiry concerning the corrosion of tin buckets. Considerable trouble was caused by the corrosion of the lower end of a pump rod of a deep-well pump. It corroded so badly that it broke and was replaced several times, as was also the lower end of the suction pipe, which extended to within 1½ ft. of the bottom of the well. The cause was never found, but it is thought to be due to the presence of sulphuric acid in the water. When the pump is at rest, the acid, being heavier than water, settles to the lowest point and forms a more concentrated solution which attacks the metal.

We presume that our analysis is correct, as only the lower end of the rod is corroded for a distance of about 18 in. above the plunger; the rest is as good as new.

We also had trouble with rusting and corroding tinware when water was allowed to stand for some time.

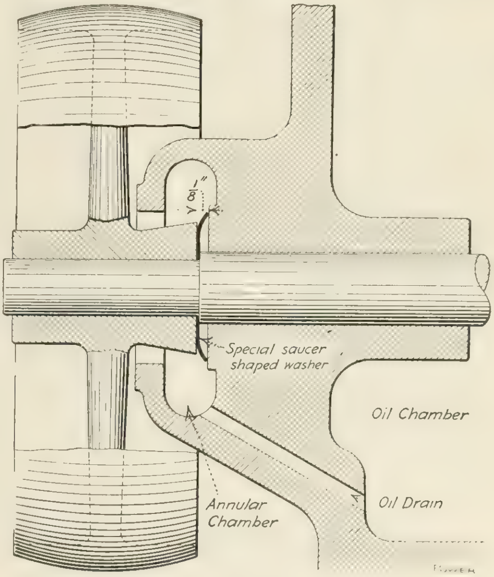
While I will not say that sulphuric acid is the cause of corrosion in Mr. Lovell's case, I think, on analysis, he will find that some such agent is responsible for it. Certainly graphite cannot do it unless there is some other compound mixed with it.

Pure graphite will never cause corrosion, and graphite paint is one of the best known protectives against corrosion. If Mr. Lovell will mix some of the graphite with boiled linseed oil to a paint consistency and then paint the buckets with it, I think he will soon find that the corrosion will cease.

Milwaukee, Wis. Frank Gartman.

Keeping Oil from Belts

On taking charge of a hydro-electric power station, I found the governor belts on each unit reeking with oil; this made it hard to maintain a constant frequency on the generators. The oil from the chamber leaked through the bearing to the pulley and belt. I cut a concentric washer of tin as large as could be put into the opening, and with a peen hammer I made it saucer shape and neatly fitted it on the shaft, which had a shoulder as shown. I first put on the tin washer, then with the pulley I forced it into its place, and drove in the cottter pin. The illustration shows the disk in place. New belts were put on and after eight months of constant work, night and day, not a trace of oil can be seen on the pulley or belt.



Disk in Place

Transvaal, South Africa. B. J. Lowe.

Engineers' Study Course

Elementary Mechanics--VII

LAST LESSON'S ANSWERS

26. In Fig. 26, let the line ABC represent the given pole and let the pressures exerted by the men be represented by the forces P_1 and P_2. The resultant of these two forces is equal to 60 + 40 = 100 lb. Hence the weight W, which is equal and opposite to the resultant, must equal 100 lb. This weight is located nearest the man supporting the greater load. The distance a may be found from the equation.

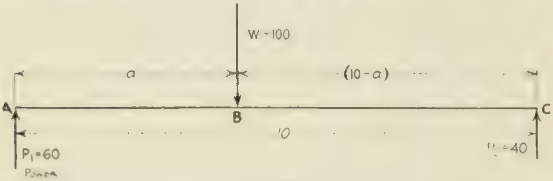


FIG. 26.

$$\frac{a}{(10 - a)} = \frac{P_2}{P_1}$$

or

$$a = \frac{P_2}{P_1}(10 - a) = \frac{40}{60}(10 - a)$$
$$= \frac{400}{60} - \frac{40\,a}{60} = \frac{20}{3} - \frac{2\,a}{3}$$
$$3\,a = 20 - 2\,a \text{ or } 5\,a = 20$$

hence $a = 4$ ft. and $(10 - a) = 6$ ft.

27. This problem illustrates a special form of couple: namely, a couple in which one of the equal and opposite parallel forces is produced by the reaction of a fixed bearing. Thus the pressure exerted by the man on the crank is one force, the distance from the center of the handle to the center of the shaft is the arm of the couple, and the second force is the reaction offered by the bearing, without the existence of which, the man could exert no pressure at all on the crank.

28. The moment arm equals 12 in., the force is 30 lb. and, therefore, the turning moment (more commonly called *torque*) produced is equal to 12 × 30 = 360 in.-lb., or 30 ft.-lb.

29. In this problem the force is 10 lb. and the moment arm is 24 in.; therefore the turning moment is

$$24 \times 10 = 240 \textit{ in.-lb., or } 20 \textit{ ft.-lb.}$$

30. The effective force tending to produce rotation of the crankshaft was found in problem 9 to equal 6000 lb. The moment arm of the force is the length of the crank which is one-half the stroke of the engine or ½ × 18 = 9 in.

Hence the turning moment is

$$9 \times 6000 = 54{,}000 \textit{ in.-lb.}$$

This moment does not remain constant since the pressure of the steam on the piston varies and also the angle between the crank and the connecting-rod.

PRINCIPLE OF MOMENTS

In the discussion on concurrent forces it was shown that, for a state of equilibrium to exist, the sum of the horizontal and vertical components must equal zero. In the case of nonconcurrent, or parallel, forces these conditions are not sufficient to insure equilibrium, for the sum of all the components might equal zero and yet there still might exist a tendency for the forces to produce rotation of the given body about a real or assumed axis. Hence the following additional condition must be fulfilled to produce equilibrium in a system of noncurrent forces:

When any number of forces acting on a body produce a state of equilibrium the algebraic sum of the moments of all these forces about any given point must equal zero. The converse of this rule does not necessarily hold true, for the sum of the moments might equal zero while there still existed either a resultant horizontal or vertical component through the point about which moments were taken.

It is to be noted that in the rule the term "any number of forces" was used without any statement being made as to the kind of forces—that is, whether concurrent or nonconcurrent. This means that the law applies equally as well to concurrent as to nonconcurrent forces, and in many instances problems can be solved more readily by moments than by the application of either the triangle or polygon of forces.

Thus in Fig. 16, Lesson IV, suppose the perpendicular distance from the point B to the line AC was 18 in. and the distance AB was 30 in. Take moments about the point B. The force P acting in the strut AB *can have no moment about the point B since the force P passes through the point B* and as the moment arm is zero, the moment must also equal zero. The only forces, then, having moments about the point B are the tension T in the rod AC and the weight W acting at the point A. The moment of $T = 18 \times T$ and the moment of $W = 30 \times W$. From the condition of equilibrium previously stated the algebraic sum of these moments must equal zero, or $18\,T - 30\,W = 0$; hence

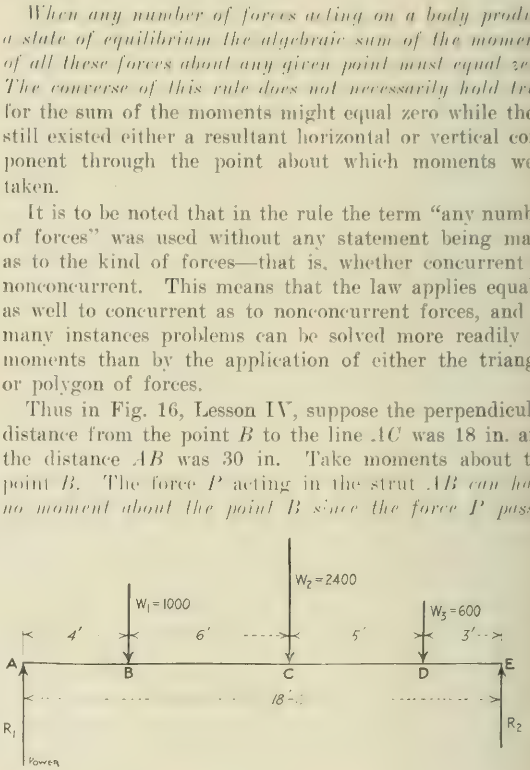


FIG. 27.

$$T = \frac{30\,W}{12} = 2.5\,W$$

For all problems involving either concurrent or nonncurrent forces then the three following equations ust always be satisfied.

$$\Sigma H = 0$$

$$\Sigma V = 0$$

ee equations (8) and (9), Lesson III).

$$\Sigma\ moments = 0 \qquad (10)$$

Since the resultant of a system of forces is a single rce that will produce the same effect on a body as the mbined action of the system it must be apparent *that e moment of the resultant is equal to the elgebraic m of the moments of all the other forces.*

A common application of this principle is in the deter-ination of the reactions of the beam. In this case the essure acting at either support or *pier* is the resultant all the other forces. The beam remains at rest, due the fact that the support exerts a reaction which is ual and opposite to the above resultant.

A practical application of this principle is made use in the design of the main bearings of an engine. The ad on each bearing can be found when the weight of e shaft and flywheel, the thrust of the connecting-rod, c., are known, by taking moments about each bearing.

Problem: A beam of 18-ft. span carries concentrated ads of 1000 lb., 2400 lb. and 600 lb. at distances of 10 and 15 ft., respectively, from the left end of the am. The beam is supported by a column placed at ch end of the span. Find the load on each column, glecting the weight of the beam.

In Fig. 27, let AE represent the beam of 18-ft. span d W_1, W_2 and W_3 the respective loads located as stated the problem. Let R_1 and R_2 be the reactions exerted the columns. The load acting on the column at E the resultant of the reaction at the point A, and the ads W_1, W_2 and W_3 The force counteracting this re-ltant is the reaction of the column at the point E dicated by the force R_2. For equilibrium the algebraic m of the moments about any point must equal zero. king moments about the point A there results the uation,

$$R_1 \times 0 + 4 \times 1000 + 10 \times 2400 + 15 \times 600 - 18 \times R_2 = 0$$

$$18 \times R_2 = 0 + 4000 + 24{,}000 + 9000 = 37{,}000$$

nce

$$R_2 = 2055\ lb.$$

like manner taking moments about the point E there sults the equation,

$$R_2 \times 0 - 3 \times 600 - 8 \times 2400 - 14 \times 1000 + 18 \times R_1 = 0$$

$$8 \times R_1 = 0 + 1800 + 19{,}200 + 14{,}000 = 35{,}000$$

nce

$$R_1 = 1945\ lb.$$

e student should study these equations carefully so as understand the use of positive and negative moments.

However, these equations do not fully satisfy the con-tion of equilibrium and the additional test of $\Sigma V =$ must be applied. From this law there results the uation,

$$-1000 - 2400 - 600 + 2055 + 1945 = 0$$

$$-4000 + 4000 = 0$$

nce all the conditions of equilibrium are satisfied and e reaction of 2055 lb. at the point E and 1945 lb. at A will keep the beam at rest under the given loads. If any error had been made in the computation of R_1 and R_2 from the equations of moments it would have been discovered when the law of $\Sigma V = 0$ was applied.

After the student has acquired confidence in problems dealing with beam reactions he will find himself determining one reaction by taking moments, and then subtracting the reaction thus found from the algebraic sum of the vertical loads to find the remaining reaction. This is not to be commended as there will be no check on the work. If, however, moments are taken about each reaction and, if the sum of the reactions found from the equations of moments does not equal the sum of the vertical loads, it means that an error has been made and the necessary corrections may be made before proceeding farther in the design of the beam.

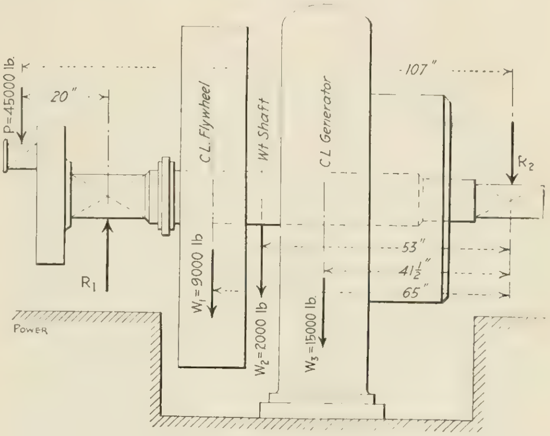


FIG. 28.

STUDY QUESTIONS

31. Fig. 28 is a diagrammatic sketch of the crankshaft of a vertical side-crank engine. The weight of the flywheel is 9000 lb. and acts at a point 65 in. from the right-hand bearing. The weight of the armature of the generator plus the magnetic pull is 15,000 lb. and acts at a point 41½ in. from the right-hand bearing. The thrust P on the crankpin is 45,000 lb. Assume the weight of the shaft as concentrated 53 in. from the right-hand bearing. Weight = 2000 lb.

Make a sketch showing the location of all the loads and the reactions.

32. Find the reactions R_1 and R_2 for the down stroke by taking moments about the points R_1 and R_2.

33. Find them for the upstroke in like manner.

34. Check the computations for 32 and 33 by making $\Sigma\ V = 0$.

35. At the instant shown in Fig. 28, does the pressure of the steam on the piston produce any turning moment on the crankshaft?

⁂

The World's Biggest Ocean Liner is to be built at Belfast, according to announcements in English newspapers. It will be of 60,000 tons, whereas the "Vaterland" is of 58,000 gross tons, the "Imperator" 52,171, the "Britannic" 50,000, the "Aquitania" 47,000, and the "Olympic" 46,369 tons. The "Britannic," launched at Belfast on Feb. 26, for safety, will have 48 of the largest lifeboats yet made, two of them fitted with powerful engines.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"You must print MY stuff just as it's wrote!"
Is what he said. And he got our goat.
All we could do was to send this note:
"Dear Sir: Sit down, you're rockin' the boat!"

⁂

Hiram Charles asks us if apiculture is the rearing of apes. No, Hi, somebody is trying to make a monkey of you. Apiculture is the rearing of the busy little bee, and offhand, it looks like you'd been stung, honey. (The "Inquiry" editor turned this over to us as irrelevant. Mebbe he has the hives. —Editor.)

⁂

Down in Venezuela they call the native soft drinks "frescos." Just think, chief, of staying out until 8.07 p.m. frescoing your town, and then hurrying home to put a dado around Fido's domicile or a frieze on the rooster's bungalow. Great sarsparilly!

⁂

Once upon a time there was a little boy who—oh, here, read it yourself!

"A little boy invented the safety valve for engines. It was his business to watch the steam pressure and let the steam off when the pressure got too high. But he wanted to play at marbles and other games free from worry. And he invented the pressure, the whirling apparatus on the top of the steam engine, which, by the power of centrifugal force, wedges apart the two revolving balls and lets the steam escape automatically when the pressure gets too high.—Editorial in "Chicago American."

Oh, piffledinks! Why didn't this editor let little Archibald keep on playing at marbles; then he wouldn't have had all this trouble with his "whirling apparatus"?

⁂

You-all, one time or another, have been amused by the factory picture that looked like it covered 149 square miles, had a forest of stacks belching volumes of dense black smoke, and a million windows, and apparently housed 65,432 employees? One concern has already been driven to say under its illustration: "All buildings here shown are part of our works." Good scheme, and enlightening.

⁂

A fire was recently caused by wire bed-springs short-circuiting a storage battery temporarily placed under the bed, says "Electrical World." The occupant sitting on the bed made the springs sag and short-circuit the battery terminals so that the wire fused, burning a hole in the mattress and setting fire to the bedding.

Here's an idea for an inventor of an old maid's patent burglar alarm; that is, if it's still true she's looking under her bed for burglars.

⁂

A Nevada miner has suggested this "safety first:"

"To the Safety Department. How to prevent accidents: Close the ——— ——— saloons.

"ROASTER PLANT."

The saloons in Dublin Gulch, says the "Engineering & Mining Journal" have the "peculiarly exasperating practice" of furnishing beer chasers. This is the best reason yet for a "dry" town. If the teetotalers love a shining mark, Dublin Gulch is a barndoor target.

⁂

Woman of 114 Attributes Age to Never Having Worried.—Headline.

Like to know how to prove a case like this. Looks as if we'd have to begin with our grandchildren, and this would start some of us to worrying right off the handle.

⁂

"Starve the railroads and we starve ourselves," says Frank Munsey. There's no getting away from it, we need the railroad if we want to get anywhere, and in the cities it brings us our eats. Two good reasons why the railroad has some rights we are bound to respect.

⁂

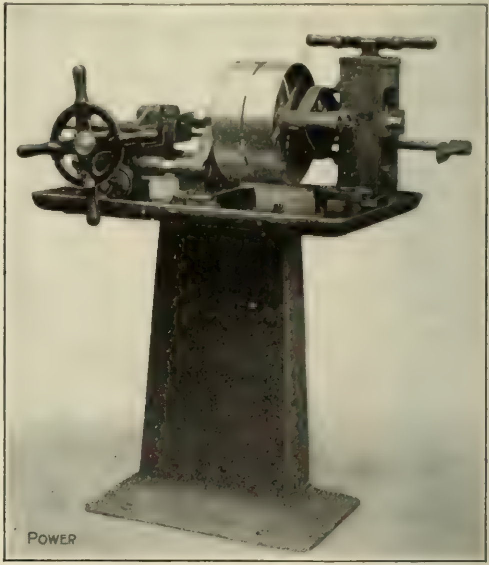
He "has light complexion and hair and sharp features" is a contemporary's partial description of an engineer impostor. Is it unusual for an impostor to have hair? Whatcha mean, "and hair"? Are just baldknobs honest? And don't you believe a baldhead never goes crazy. They're all crazy—to grow some hair. And hair! Why not tell how many? An easy task for those who are coaxing a few on very evident false pretenses.

Oster Cutting-Off and Reaming Machine

This machine is designed to cut off and ream pipes in all sizes up to 2 in. in diameter. It is provided with a large single, stationary wheel tube cutter mounted on a steel pinion which rests in a bronze bearing.

The pipe to be cut off rests on a pair of rollers, and by a turn of the handwheel at the top of the machine, the pipe is brought in contact with the cutting disk and is quickly severed. A slight pressure on the handwheel regulates the speed of cutting off.

The two rollers which support the pipe while cutting off are made of steel and revolve in tempered-steel bearings. The rollers which support the pipe rest on the bottom of a yoke which slides up and down in the frame. The disk cutter can easily be removed for sharpening or renewal. The gage rod is adjustable for the different lengths of pipe to be cut off.



Oster Cutting-Off and Reaming Machine

In reaming, the pipe is held in the vise jaws, which are opened or closed by a movement of the handwheel at the side of the vise. The open vise enables the operator to quickly change the work.

Pressure of the pipe against the reamer is brought about by the handle mounted behind the vise wheel, which moves the vise back and forth. The vise is solidly mounted on this frame.

The reamer is held fast by a setscrew; it can be easily removed for sharpening when necessary.

This machine is built by the Oster Manufacturing Co., Cleveland, Ohio.

⁂

Winnipeg (Man.) Owns Its Public Utilities, among which are the electrical works, at Point du Bois on the Winnipeg River, 77 miles northeast of the city. The waterfall, naturally 32 ft., has been increased by the power-development dam to 47 ft., with a pond of 6000 acres. The total power available, without storage, is 60,000 hp., which can be increased to 100,000 hp. These works, including generating stations, completed and equipped, cost Winnipeg $5,000,000.

Fuel Pumps and Compressors of Oil Engines

By Frank E. Booth

Heavy oils when used in oil engines are atomized by means of compressed air; hence the continuous and satisfactory operation of the engine depends largely on the oil pump and air compressor.

Oil Pump

The oil and air pipes are both directly connected with the atomizer. The air pressure may be anywhere between 300 and 1200 lb., and a little dirt on the check valve of the oil pump may cause it to refuse to deliver against this pressure and cause a shutdown. For this reason, the fuel should be run through a screen before entering the oil-supply tank. Multiple check valves in series reduce the liability of shutdown from this cause as the chances are that both valves will not be fouled at the same time.

Furthermore, there should be no air pockets or traps in the interior of the pump as air bubbles will interfere with the operation of the pump. If the pump plunger is worked by hand, a spring effect caused by air bubbles is quickly detected. A stroke with uniform pressure from start to finish indicates an absence of air.

If the engine has been shut down for some time, air may get in the suction pipe and make it impossible to start. A bypass connecting the discharge pipe with the suction and having an air chamber in the line, may be used for freeing the pump of air. When operating the pump by hand with the bypass open, the air lodges in the air chamber and is liberated through a petcock at the top.

The oil is likely to carry in suspension a certain amount of water, and when the engine is shut down this water accumulates at the bottom of the oil tank; if it is not drained off, the engine will miss fire when starting. The pipe should enter the oil tank three or more inches from the bottom and a faucet should be placed near the bottom to take care of the water.

Candlewick rubbed well with soap and graphite makes a good packing for the pump plunger. The pipe joints may be made up with litharge and glycerin or shellac. Moreover, the oil pump should have surplus capacity to take care of any small leaks which might occur during peration.

Air Compressors

A two-stage tandem air compressor has pressure behind he piston all the time, making a smoth-running mahine by keeping the slack in one direction. There should e some adjustment endways so that the piston clearance may be kept at a minimum and the valves should be nged so that a duplicate one might be inserted at short otice.

A little soapy water fed through the low-pressure int helps to keep the valves clean. Too much lubricating l will foul them as it chars with the heat, the carbon us formed causing the discharge valves to stick. Somemes too much oil also causes explosions in the compressor.

If the low-pressure inlet of the compressor be coupled to the air-inlet pipe of the engine, the compressor will make very little noise. A safety valve should be placed in the air line between the compressor and the tank. This relieves the pressure should the tank valve be closed by mistake. It may be noted that when the compressor is in good order, the low-pressure discharge pipe is not as hot as the high-pressure, which fact helps one to locate trouble. If the high-pressure discharge valve is leaking, the low-pressure discharge pipe will be much hotter than usual; the low-pressure discharge pipe is not hot when trouble exists in the low-pressure end. A pressure gage on the intermediate receiver will also help to locate trouble.

Sometimes the compressor is working all right when the pressure gage indicates a loss. This may be due to a leak in the air line, a leak in the sprayer valve proper or around the valve spindle; moreover, the sprayer valve may stay open too long, caused by too great a lift or too long a contact with the cam.

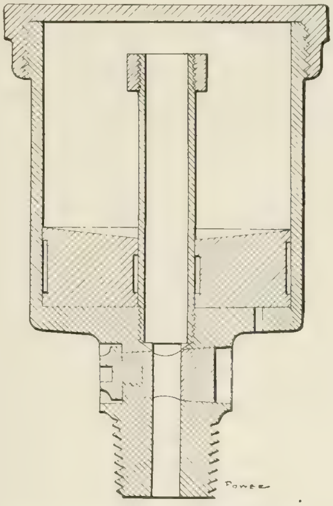
If one cylinder in a multicylinder engine cuts out, which sometimes happens on light loads, the reduced pressure in the cylinder allows more spraying air to go through the valve. Also, an engine valve not seating properly causes reduced compression and lower initial pressure with a loss of spraying air.

⁂

Organ Centrifugal Grease Cup

This centrifugal grease cup is used primarily for loose pulleys and thrust bearings, the grease feeding through the cup only when the bearing is moving.

It consists of a shell threaded at the shank on the lower end to fit in the hub of the pulley. The top is a cap which screws onto the cup. On the inside is a piston which slides on a stationary tube, capped at the top with a stop nut. In the shank is a regulating plug for controlling the feeding of the grease.



Section of Organ Grease Cup

In operation, the centrifugal force presses the movable piston against the grease, causing it to flow through the center tube to the bearing. When the cup is empty, the cap is removed and the cup filled with grease on top of the piston. This cup is made by the Keystone Lubricating Co., Twenty-first, Clearfield and Lippincott Sts., Philadelphia, Penn.

Selection of Refractory Materials

By Morgan B. Smith

SYNOPSIS—An outline of tests to determine the quality of firebricks and fireclay.

⁂

The purpose of refractories for power-plant use is a problem which every purchasing agent or chief engineer has to solve sooner or later in the course of operation. In this problem two factors are prominent, namely, the utility for which the refractory material is to be purchased, and, secondly, the refractory itself. The utility is, of course, predetermined by the purchaser; the general essential characteristics of the required refractory are known; the question then is to find a refractory which possesses these requirements.

The tests which a purchaser may make follow certain well defined lines in which the essential characteristics are brought out under conditions closely simulating those of practice. As a matter of fact, it is always good policy to maintain the conditions of the tests somewhat more severe than in practice for the customer is wise in insisting on a certain margin in the way of service from a refractory material, i.e., he has the right to demand materials somewhat better than the utility actually demands.

Inasmuch as refractory materials, firebrick and fireclay, are used in power stations mainly for the linings of the combustion chambers and arches of boiler furnaces, the tests which have been found essential will be outlined.

Measurements

General dimensions in inches (or centimeters), accurate to $\frac{1}{32}$-in., should be taken. From these figures the volume is figured and the relation between the volume found and that of a standard brick of the same shape established. From this ratio the estimating engineer can figure the amounts necessary for the given utility.

Calipered measurements are to be taken before and after heat tests of length, breadth and thickness, each dimension being taken at two different points so as to assure a fair average in the measurements. These figures give the change in size, due to heat tests, or, in fact, any tests which may tend to distort the shape of the firebrick. Change in size is one of the best indications of the future behavior of the firebrick under practice conditions, especially if this information is combined with that obtained from the load test given below.

Weight

The weight is of importance as a rule to the constructing engineer as it gives him an idea as to the mass to be carried by his structural work and indeed by the refractory itself. The weight figure is also of use in figuring the density of the material. This is generally taken in pounds and ounces, but may be in kilos and grams if greater accuracy is desired.

Porosity

This is generally determined by determining the amount of water which the brick will absorb in a given time. It is also a measure, indirectly, of the density of the material; also of the degree of "burn" and, in a measure, of the load-carrying ability.

High-Temperature Tests

In these tests the temperature must be somewhat higher than that to which the refractory would be subjected in practice and must be maintained over a considerable length of time in order that all the characteristics of the material sensitive to heat may be developed and the phenomena noted. All the conditions of practice should be duplicated insofar as is practicable, including the action of coal ash, coal gases, clinker, etc. Such tests can be run along with the simple heat tests in the same furnace and consist of burning the coal to be used in the boiler furnace on top of the firebrick being tested, the coal being renewed as fast as it burns away. In this way the tendency of the firebrick and ash or clinker to react and flux each other may be noted. The author has found that very often a refractory which stands up under the high temperatures splendidly, fails utterly when maintained at the same temperature in contact with coal ash or clinker.

Pyrometry of Heat Regulation

In high-temperature tests it is absolutely essential that the temperature be determined and maintained by means of some form of accurate pyrometric control. This is so because of the desirability of being able to duplicate conditions in check tests and also because of the fact that the accurate evaluation of the refractory demands it. For moderate temperatures, not exceeding 1000 deg. C., the platinum-resistance thermometer is probably the ideal outfit, although there are so called base-metal pyrometers which are satisfactory under general conditions. The latter have one advantage over the former type, namely, that they are fairly accurate at the lower temperatures and may also be used at temperatures higher than the former type will stand.

For high temperatures, up to 1550 deg. C., there is a choice between two types, the platinum-platinum-rhodium couple and the radiation pyrometers. The latter is too delicate an instrument for general use around power stations and the extreme temperature range of this instrument is not required for such work. The platinum-platinum-rhodium couple with its sensitive indicator must be calibrated from time to time against the known temperatures of metals or salts, a list of the more common points being given below.

Element	Melting Point, Deg. F.
Tin	450
Cadmium	610
Zinc	786
Antimony	1166
Aluminum	1216
Calcium	1481
Barium	1562
Silver	1762
Gold	1945
Copper	1981
Nickel	2642
Palladium	2822
Platinum	3191
Tungsten	5432

From the above elements a selection may be made according to the range of the tests in question and the pyrometer standardized accordingly. It is best to select points covering a fairly wide range, for then the temperature curve of the pyrometer will be more nearly correct than if only a few, closely related points are taken. The zero for the couple is taken at the temperature of melting ice and the cold end of the couple must always be used at the same temperature as when the zero is established or else somewhat uncertain corrections must be made. If possible the cold end should be either water or steam jacketed to assure a uniform temperature.

There are also the older pyrometric indicators, such as the Seger cones, which give good results when only momentary temperature indications are essential. As a rule, they are accurate when used properly, they must not be allowed to soak at temperatures lower than that which they are supposed to indicate for they will almost invariably bend under such treatment and so indicate a temperature really higher than exists. They should be heated up carefully outside of the furnace where they are to be used and, when thoroughly heated through, should be inserted into the test furnace. They will then come quickly to the temperature of the furnace and will not give false indications. The author has noticed, for example, that the cone which indicated 1370 deg. C. under normal treatment gave just as good an indication when held at 1320 deg. for a comparatively short time. With a little practice the use of the electro pyrometer and the cones may be combined to good advantage as the cones serve as a ready check on the accuracy of the pyrometer during a test run.

Load Tests at High Temperatures

These tests are essential, for they give the real capacity of the firebrick to stand up under load at high temperaures. It is frequently found that a brick which is strong at ordinary temperatures becomes easily crushed and often will bear no load at all in proportion to that which t must carry in practice when heated to a high degree. There are two ways of conducting such a load test, namely, by testing a single brick and by testing a mass f the test bricks generally laid up in the form of a pier.

In the first case the test brick is supported above the oor of the test furnace by the ends and is weighted in he center on top with a weight proportional to the load hich the brick must carry in practice. In the second ase no load is added unless it is necessary to do so to ring the load up to that found in practice. The pier s built in the furnace, projects through the roof and arries its load (if any) upon its top. Measurements of he pier before and after the test give a measure of the oad-carrying capacity of the brick in question.

In general practice around power stations the test on ngle bricks has been found satisfactory, especially if ways carried out on some particular standard shape, ich as an ordinary 9-in. straight, as then all tests beome comparative. For general utilities a 9-in. straight rebrick should be supported on two soap bricks 2¼ in. f the floor and 7 in. clear of supports. This gives the rick 1-in. bearing at each end. The weight used is enerally 7.5 lb., made by trimming a magnesite, or beter, a chrome firebrick. The load, however, as stated bove, must be determined in proportion to that carried practice. Many an arch failure might have been verted had such a load test been carried out at or near e temperature maintained in practice.

Abrasion Tests

It is not often that these tests are conducted on refractories used in boiler furnaces, but there are certain phases of this test which are of value, especially where firebrick are used in the linings of furnaces heated with inclined grates, such as the Roney, where there is at times severe abrasive action, due to the constant steady motion of the fuel down the grates and along the brick surfaces. Such tests should be carried out at as high a temperature as is practicable since the resistance to abrasion varies with the temperature of the brick.

An apparatus for abrading firebrick may be made by studding an iron or steel plate with many soft-iron stove bolts, or similar material, which may be renewed from time to time as they wear away. The plate is drawn back and forth over the surface of the brick a definite number of times and the material worn away weighed. It is also possible to apply the rattler test, commonly applied to building and paving brick, to firebrick with good results if the firebrick are hard burned and fairly close grained.

Shock Tests

These tests are carried out to determine a firebrick's resistance to sudden changes in temperature. The firebrick is heated to the desired temperature, is withdrawn from the furnace at full heat and is immediately plunged in cold water or buried in wet, finely ground coal. It is then removed from the water or coal and examined, after which it is again heated and chilled if desirable. A firebrick should stand this test without checking or spawling. The test simulates, in a degree, the conditions in a boiler furnace when fires are banked quickly or when the boiler is taken off of bank and the fires are brought up to full intensity in a short period of time.

Firebrick vs. Fireclay

Needless to say it is of great importance in laying up firebrick to know what may be expected of the fireclay with which bonds are effected and joints made tight. A fireclay, to fill its utility, must make good bonds between the firebrick and must produce permanently tight joints. It must do this without inducing undue fusion in the firebrick and must not fuse unduly itself.

A good way to test out a fireclay is to lay up the two halves of a split 9-in. firebrick, as in practice, with the clay in question, rubbing down joints carefully. This test piece is then heated to the desired temperature for a stated length of time and results noted. As a rule, the fireclay should be of a slightly lower degree of refractoriness than the firebrick with which it is to be used. This statement is made, however, with caution, for it is only by test that the proper degree of refractoriness of a fireclay can be determined for use with a certain brick under certain conditions. It is well to remember that the less fireclay used the better, so long as the desired function of the clay is attained.

Physical Tests

As a rule, physical tests, such as resistance to crushing load, are not applied to firebrick used for furnace construction. Some data may be obtained, however, in special cases which is of value, but the fact must be kept in mind that temperature plays a large part in tests of this character and the results of these tests at ordinary temperatures must be considered along with the load tests at high temperatures. At best, physical tests at ordinary temperatures are a measure of the general workmanship, the degree of burn and the condition of the bonding of a firebrick.

Heat Conductivity

In the case of boiler-furnace refractories, heat conductivity is not desired, rather the reverse, for it is by reflection of heat that the gases of combustion of coal are ignited. It is equally true that those bricks which show a comparatively low degree of conductivity give the longest service. As a matter of fact, the brick composing the lining of the combustion chamber should also show a low degree of conductivity so that the radiation losses may be cut down as much as possible.

Heat conductivity is best determined by the calorimetric method in which the heat imparted to a known volume of water is measured over a stated period of time. There are other methods in which the penetration of heat into a firebrick is measured by inserting pyrometric couples into the brick to varying depths and the temperatures noted. In such tests one end of the brick is maintained at a definite temperature, the pyrometer couples indicating the fall in temperature away from the hot end of the brick. These tests are purely comparative, and do not give the actual conductivity.

General Data

Under the heading General Data may be included notes on the following characteristics: Workmanship; degree of burn; indications of the presence of fluxes, such as alkalies, ferrous iron, titanium oxide, etc.; size of grain, its compactness or looseness; tendency to spawl or otherwise; surface checks or cracks; conditions of the "skin"; behavior when cut, its tendency to ravel or otherwise; the condition after heat tests and load tests at high temperatures.

Analysis—Ultimate and Rational

The ultimate analysis is of value in that it affords the opportunity to calculate the probable degree of refractoriness by the so called "Bischoff number," in which case the refractoriness is referred to the relative proportion of the silica, alumina and fluxes found by analysis, according to the formula:

$$a\ \mathrm{Al_2O_3} + b\ \mathrm{SiO_2} + \mathrm{RO}$$

where RO is taken as the unit representing the fluxes, *a* and *b* indicating the amount of alumina and silica in proportion to the fluxes. Bischoff suggests that the degree of refractoriness be shown by the formula: a^2/b, that clay which gave the highest "number" by this formula to be considered the most refractory. This method is somewhat uncertain, for some clays give figures which correspond well with the direct fusing tests, whereas others do not.

The rational analysis, in which an attempt is made to separate the clay into its mineralogical constituents, is of value along with the ultimate analysis when carried out properly. It requires much experience to get accurate results.

The tests, as outlined above, will give satisfactory results when conducted with care and with a proper sense of the character of the refractory and of the utility. The best test of a refractory in the long run is its actual use for the given utility and whenever possible such practical tests should be conducted.

Alberger Multihead Heater

When heating feed water from 40 or 50 deg. to within a few degrees of the temperature of the steam, the most severe treatment the heater gets is when it is placed in service after being cold, at which time the tubes are all of one length. There will also be an unequal elongation of the tubes, due to the change of temperature which unless taken care of, creates strains in the tubes and tube heads.

An effective design of heater has recently been developed by the Alberger Heater Co., Chicago and Granger Sts., Buffalo, N. Y. Several groups of tubes are permitted to expand or contract free from each other, by means of floating-tube heads which hold the tubes containing hot water. The heads may assume a position, say, ¼ in. further away from the stationary-tube head at the opposite end, than the floating-tube head holding the tubes which contain cold water (Fig. 1), and no

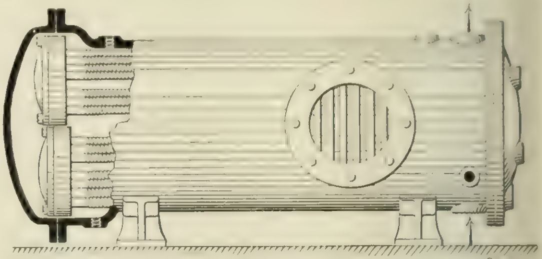


Fig. 1. Heater with Double Floating-Tube Heads

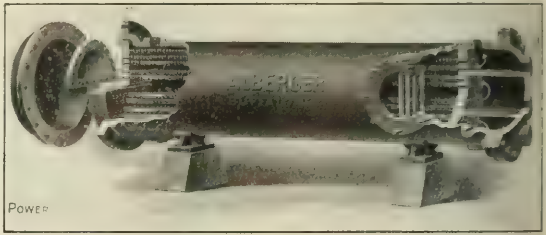


Fig. 2. Multihead Water Heater

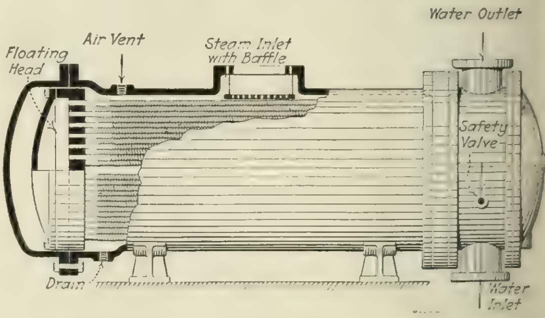


Fig. 3. Single Head in Two-Pass Heater

harm can result from the unequal expansion or contraction.

In Fig. 2 is shown a design for heating boiler-feed water wherein a multihead design is used. It is of the four-pass construction. The right-hand tube head is secured to the shell, but the floating-tube heads at the opposite end of the shell are free to move independently. The tubes are expanded at both ends into the tube heads and no packings are used. The cold feed water enters at one end of the heater at the bottom and passes through it four times in the direction of the arrows, discharging at the same end and at the top. As all steam and feed connections are made directly on the shell it is not necessary to break these pipe connections to obtain access to the heating surface for cleaning or inspection. All heaters are supplied with baffle-plates to protect the tubes from the impact of the incoming steam, and assist in distributing the steam over the heating surface.

The hot-water service or domestic supply heater, such as is used in hotels, hospitals, etc., follows the same construction. As the service this heater is required to perform is unusually severe, the multihead arrangement should be used to prevent trouble.

For the forced-circulating heating system the water is usually passed through the heater twice because of the large quantity of water to be handled, and as the temperature range, usually from 20 to 25 deg., is very small, the multihead arrangement is not necessary. In such a heater a single floating head is used, as illustrated in Fig. 3.

In all heaters a seamless-drawn copper tube, which is 99.8 per cent. pure copper, is used. The corrugated tube was adopted in order to obtain a high rate of heat transmission. The corrugations are not depended upon to take care of the expansion or contraction. All tubes are expanded rigidly into the tube heads.

The induction or dead-end principle is used largely, although a steam-outlet connection can be furnished if the conditions demand. The heater is made in either the vertical or the horizontal type.

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Boiler Inspections*

By S. F. Jeter†

The present-day "safety first" movement has apparently take all by storm, but if full credit is to be given where credit is due, it must be remembered that boiler inspection was the first "safety first" movement. It is the first duty of the boiler inspector to endeavor to prevent accidents to the boilers under his care.

He must, of course, know boilers thoroughly; so well, in fact, that he feels confident his recommendations or demands are absolutely right. His backbone must be without joints when it comes to arguing a case regarding changes that are necessary for safety.

He should be built like a camel, gastronomically, and learn to eat and drink when he reaches a point where food may be obtained. These requirements do not particularly apply to New England inspectors; in the West and South it is a real and necessary qualification. Boiler inspections are divided into two general classes, usually termed external and internal, but the names would better designate their nature if they were called operating and general inspections. The external is usually made without any previous notice to the assured, and the inspector's duties in connection with this inspection are such that the operation of the plant is in no way interfered with, providing, of course, everything is found in order.

To make an internal inspection, it is necessary that the boiler be idle and empty and that the manhole and handhole plates be removed as well as otherwise prepared for examination. I will first describe the internal or general inspection because the first of such inspections is the one required for the approval of the risk for insurance, and I can assure you that finding the boilers is sometimes no mean part of the inspector's task.

On arriving at the plant he usually meets the chief engineer and other plant attendants. At this meeting the inspector's ability to size up his man is most necessary, because the plant employee can make his task difficult or otherwise, as he may see fit, and he also can be of inestimable value in imparting information regarding operating conditions which the inspector could not hope to obtain in any other way. Often a minor accident has resulted in the injury or death of an employee—causing mental anguish as well as physical pain, and, besides, an expense to the assured or insuring company which could have been prevented by providing reasonable means of exit.

The blow-off connection is a fruitful source of such accidents. The blow-off valve is frequently so placed that the man operating it is in a closely confined space, with the piping so arranged that a break at any point during the act of blowing off is likely to cut off all means of his escape. It is the inspector's duty to recommend the necessary changes required to prevent such an occurrence. The steam and water piping, as a whole has to be carefully considered to see that there are no connections which may lead to accidents or dangerous conditions of operation. The feed appliances, such as pumps, injectors, etc., and the piping between them and the boilers, must be inspected for safety as well as general plan and capacity, so that the boilers may at all times be supplied with an abundance of water to meet their maximum capacity.

SOME FIRST THINGS TO EXAMINE

With separately set boilers the connecting pipes to the water space must be examined to see that it is separate and distinct, with check valves properly arranged to prevent the transfer of water from one boiler to another. In some cases, where the heating plants work on low pressures and gravity returns, it is found best to do away with check valves between the boilers. The steam pipe must be so arranged that no pockets will be formed to trap the condensation and it must also be so connected that the movement due to the expansion and contraction can take place without undue strain on any of the parts. Many lives have been sacrificed owing to a lack of precaution and forethought in suitably arranging steam piping.

An examination must be made of the connections and attachments for determining the water level, for it matters not how strongly a boiler is built if the water line is continually carried even a small amount below the fire line: disaster is almost certain to follow sooner or later. Water columns are frequently found set so low that the safety of the boiler is endangered. The blow-off or drain connection from the water column is examined to see that its size is ample. The connection from the steam space of the boiler to the top of the water column must be inspected to see that there are no connections on this pipe that are required to furnish a supply of steam for any other apparatus, or that water can be trapped in the pipe. Either of these conditions will render the indications of the water level inaccurate. Whether the location of the steam gage is correct must be determined; frequently it is so connected to a boiler that the steam comes in direct contact with the spring or it is so fastened that it is exposed to heat from some part of the boiler or smoke flue, either of which conditions renders its indications inaccurate. The safety valve is a most important attachment and deserves the closest scrutiny to determine its condition. The escape pipe from a safety valve is another frequent source of danger, and the inspector must see that it is properly drained and well supported to prevent undue strain on the valve.

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*Abstract from a paper read before the Insurance Institute of Hartford, April 7, 1914.

†Supervising inspector of the Hartford Steam Boiler Inspection & Insurance Co.

If the boilers are of the suspended type, the ability of the supports to safely carry the load must be determined. This usually requires complete data of columns and supporting members as well as sizes of hangers, etc. The determination as to whether each support is carrying its proper proportion of the load is necessarily made, for proper boiler support is just as important as regards its safety as is its strength in any other respect.

THE INTERNAL INSPECTION

The inspector, after writing the answers asked on his data slip regarding the various parts examined so far, then enters the top manhole with a light, a rule, calipers, a hammer and usually a depth gage. He first carefully examines the condition of the parts, the shell may show evidences of pitting, especially along and just below the water line; the tubes may be pitted or thin from general corrosion; the braces may be weakened by corrosion or they may be loose, due to strain or improper fitting. The soundness of the braces is usually determined by striking them with the hammer as well as by visual inspection, and the shell is carefully sounded to determine if there are indications of cracks or laminations in the shell material. Many of the rivets are sounded for tightness. The condition of the upper portion of the boiler as regards scale or oil deposits is ascertained, and it is not uncommon to find the spaces between the tubes against the rear heads completely stopped with scale for a foot or more. Such conditions are likely to lead to serious trouble, if not explosion. Any indication of oil in a boiler is a serious matter; there is no substance likely to reach the interior of such a vessel that can produce an effect at such wide variance with the apparently harmless nature of the cause.

All openings to outside attachments or connections are examined to see if they are free, as many boiler explosions have been caused by a stoppage of the water-column connection. Where the connections are supplied with a pipe screwed into a part of the boiler or into a flange riveted to the shell, the inspector must note whether the screwed joint has been fully made. Since this inspection is assumed to be the first one made of the boilers under question, the inspector must obtain the necessary data for calculating the strength; he must know the distance between the shell and the tops of the tubes to correctly estimate the amount of bracing required; he must know the number and the size of the braces at their least section on each head. The number and the size of the rivets attaching the braces to both the head and the shell must be known so that the weakest element in the construction can be taken into account in calculating the strength. The thickness of the heads must be ascertained in order to estimate the strength of any unstayed surfaces and to judge whether a suitable bearing surface has been supplied against which the tubes were expanded. The pitch and the size of the rivets must be obtained as well as the design of the joint, so that its strength relative to that of the solid plate may be determined.

The size of the rivets is usually judged from the dimensions of their heads. The thickness of the shell, which must be known, can usually be measured by means of a depth gage applied along the edges of the plate at the girth seams, and may be calipered at an opening in the shell. If there is a dome, the details regarding the bracing of the head as well as those of the connection to the shell must be secured as well as the dimensions of the reinforcement around the opening from the boiler to the dome should this opening be large.

Upon coming out of the boiler, the inspector can place the data obtained on the data slip, but he usually waits until after completing his inspection. The layman might think it a difficult feat to commit all of these measurements to memory, but the average inspector can generally repeat offhand the principal data of a boiler several weeks after taking it.

The next point to be examined is the interior below the tubes if the boiler is supplied with a manhole communicating with this part of the structure. The usual points to be given attention here are the soundness of the bracing, the condition of the shell as regard corrosion or other defects; the heads and tubes, and to note the quality and quantity of the scale attached to the surfaces. Quality of scale is just as important as quantity as regards its ability to injure a boiler or detract from its economical operation. The tube-cleaner salesman and the boiler-compound man frequently quote tables giving the different efficiencies of operation due to fixed thicknesses of scale is boilers. While there is more or less regular change in the efficiency of a boiler with carrying thicknesses of scale of the same quality, it is pure buncombe to state that a given thickness of any kind of scale will reduce the efficiency a fixed amount.

Proper makeup of the blow-off pipe is determined while the inspector is in the lower part of the boiler. If there is no manhole below the tubes, the information just specified is determined as well as possible while in the upper part of the boiler, and also through the hand holes, which are usually supplied in the front and rear heads.

After completing the internal inspection, the inspector should examine the front heads externally. Here corrosion of the head and the tube ends is likely to occur, especiall if the boiler is fitted with a stack connected directly to the extension sheet, for under these conditions rain may come down the stack during idle periods, and the sulphur deposit in the stack and on the head from the furnace gases, combined with the moisture, causes extremely rapid corrosion. The inspector must next examine the front to determine that no weight of the boiler is carried on it, unless it should happen to be one of the type, now rapidly disappearing, which is designed to carry the weight of the front end.

EXAMINING THE FURNACE

The inspector next enters the furnace and notes the condition of the fire sheets and the seams, and he should make a careful examination of the surfaces to locate any brands or stamps placed on the sheets by the manufacturers, and from which the tensile strength of the plate can usually be obtained. If rivets leak, it is the outside of the boiler that usually reveals this fact, and when leakage is discovered its cause has to be ascertained, so that necessary recommendations can be made. Leakage of the girth seams can be caused in many ways; if from scale or oil deposit, the inspection of the interior already made will generally reveal the cause. Poor workmanship will usually be evident to the experienced inspector.

The location, the shape and the size of the bridge-wall which forms the rear limit of the grate surface is often the cause or contributes to leakage at the girth seams. In many types of boilers the improper support is also a contributing cause. Feeding in the bottom of the boiler through the blow-off connection is another fruitful source of such trouble. The inspector must examine into all of these phases and must recommend the necessary changes.

The inspector must keep a sharp eye for evidences of leaks coming from the vicinity of longitudinal seams, as any such leak must be regarded with the gravest suspicion as the cause is likely to prove a hidden crack. This defect has been responsible for some of the worst explosions in the history of steam boilers and no leak at a longitudinal seam should be considered harmless until it has been so proved.

The condition of the setting walls must be known to the inspector, particularly with respect to their ability to properly support the boiler. The blow-off pipe should be examined to see that it is sound and free at the bottom—that is, that no weight is resting on it. This is a common source of accident. The freedom of the blow-off pipe where it passes through the setting wall is also essential to safety, as is the proper protection of the pipe from the direct impingement of the flame and the highly heated gases from the furnace.

The rear tube ends must be examined for leakage and for corrosion, and if the defects are disclosed, the cause must be determined and the proper recommendations made. The condition and the position of the covering over the rear combustion chamber must be examined into, as the arches generally used at this point are frequently located so high as to cause the overheating of the head above the water line. The fusible plug which is located in the rear head must be inspected to see that the fusible metal is in proper condition to respond to an increase in temperature should low water occur. After examining the blow-off valve and the outer portion of the pipe, the inspector is ready to test and, if necessary, to correct the steam gage. Then the inspection is completed.

After the inspection the inspector usually discusses the various points revealed by his examination with the chief engineer, and directs him in regard to the making of repairs or to the betterment of operating conditions. Inquiry should be made as to the maximum steam pressure required to properly operate the machinery used in connection with the plant as this should be given due consideration in fixing the maximum pressure to be allowed.

THE EXTERNAL INSPECTION

While the external inspection is not nearly so complete as the internal, it is, notwithstanding, a most important inspection. Operating conditions can be observed at such an inspection and dangerous practices stopped before it is too late to check their effect on the boilers. The inspector has a card or list indicating the allowed pressure on the boilers to be inspected, and on entering the boiler room he should note the gage pressure carried, and whether all the gages register alike.

The water column must be blown down to determine the freedom of the connections leading to the column, this being made readily evident by the speed with which the water returns to its original level as well as the behavior of the water in the gage glass if the boiler is steaming. The gage cocks should be tried to see if they are free and in operating condition. An examination is next made of the fire surfaces of the boiler and the conditions of the furnace walls, as far as can be ascertained from the furnace doors. Notice is also taken of any tendency toward leakage or bagging or blistering of the plates. The front flue doors are opened in order to view the tube ends, which are examined for leakage and general conditions.

The rear of the boilers is now to be visited and the condition of the blow-off valve and connection is determined as far as their operating condition is concerned. There is frequently a cleaning door in the rear setting wall in such position that the fire surfaces and possibly the rear tube ends may be examined from this point.

The inspector next visits the top of the boilers and, ascertaining the steam pressure at the time, he tries the safety valves or has the engineer try them. With a safety valve of either the spring-loaded type or of the ball-and-lever design, and with the steam pressure not over 20 per cent. less than the pressure for which the valve is set, an accurate idea of the pressure at which a safety valve will operate can be obtained by testing the freedom of the valve by hand. If the safety valve does not appear to be properly adjusted, the inspector requires that steam be raised until the valve operates in the regular manner or until the increase in pressure positively demonstrates that it is set for a pressure in excess of the limit allowed.

One of the most important features regarding the external inspection is the discussion of plant conditions with the employees, for information of the greatest value, both to the assured and the insuring company, is often obtained in this way.

The mistakes of the inspector always stand out in bold relief after an accident, as does the soundness of his advice when compliance with his recommendations and demands can be assumed to have prevented the accident, but how many explosions are prevented by timely warning and advice can never be known.

In conclusion, I say that the subject allotted to me is so broad that I have been able to touch only on the regular inspection of one of the simplest types of boilers, while there are many different types, practically all of which are far more complicated than the one discussed.

The Manufacture of Steel Pipe

At a meeting of the Northeastern Section of the American Chemical Society in Boston, Mass., on Apr. 24, Dr. William H. Walker, of the Massachusetts Institute of Technology, gave a lecture upon the manufacture of steel pipe, reviewing the process from the sampling of ore at the mines to the testing of the finished product. A résumé of the lecture is printed herewith.

Iron is one of the most widely distributed elements in nature, but it is practically always found in combination with other substances, occurring largely in the oxide form. Chemically pure iron is extremely rare; its separation in the laboratory is a long and tedious process, and few engineers ever see it freed from combination with other elements. The production of pig iron in the United States has increased from 8,000,000 tons in 1896 to 31,000,000 tons per year at present. Forty-one per cent. of the total output comes from Pennsylvania, 23 per cent. from the Great Lakes District, 9 per cent. from Illinois, 4 per cent. from New York, and 6 per cent. from Alabama. The large coal deposits of Pennsylvania are important factors in the cheap local production of iron and steel. Some of the largest plants on this continent are the Gary, Ind., works of the Indiana Steel Co., the Lorain, Ohio, works of the National Tube Co., and the Chicago plant of the Illinois Steel Co.

The Lake Superior district is the largest producer of iron ore, and the Mesaba Range in Minnesota is the most famous present source of the raw material of the pipe industry. From the range to the steel mills of Pittsburgh, the distance is about 1000 miles. The ore beds are sometimes 600 ft. deep, with a heavy overhang. Steam shovels, efficient ore cars, excellent docking facilities and the loading of steamers by gravity are utilized to the fullest extent. An average steamer cargo of ore weighs 13,000 tons, and such a boat can be loaded in 31 minutes.

Unloading by cranes and multiple buckets consumes four hours. A modern blast furnace will produce 500 tons of iron in 24 hours, the furnace being 100 ft. high and 22 ft. in diameter at the bottom. To produce one ton of iron in a blast furnace there must be supplied eight tons of air, four tons of ore, two tons of coke and ½ ton of limestone. The furnace is tapped every four hours and the iron is tapped into sand molds or into ladles as conditions require. In a modern blast furnace 40,000 cu.ft. of air per minute is supplied at a temperature of 400 deg. C., and a pressure of 15 lb. per square inch. At Gary, all the gases of the furnaces are burned and enough power is produced by the gas engine and electric generating plant to operate the rolling mill, a cement plant and other establishments. Eight blast furnaces are installed at Gary.

From the blast furnace the iron is run into a metal mixer of 600 tons capacity, which reduces the casts from different furnaces to uniform temperature conditions, impurities being later removed in a Bessemer converter. When the iron has been purified by blowing air through the charge of metal in the converter, the charge is emptied into a traveling ladle and at the same time a certain amount of molten spiegeleisen is poured into the ladle with the iron to introduce into the metal a proper amount of carbon and manganese for the grade of steel required.

In usual practice a train of cast-iron ingot molds, with two ingots to the truck, is drawn by an engine beneath the pouring stand, and the hot metal is run into the molds through a nozzle in the base of the pouring ladle. As soon as the ingot is set, the mold is drawn from it by a hydraulic stripper, and it is lifted by an electric crane, and lowered into a soaking pit or heating furnace, where it is raised to the proper temperature for rolling. From the soaking pit the ingot is taken to the mill and passed through the blooming rolls, which reduce it in section ready for shearing into slabs and billets. Electromagnets are extensively used in handling billets. The billets in manufacturing pipe are reheated and passed through a continuous mill consisting of a large number of rolls in pairs, placed one beyond the other at increasing intervals. As the billets or slabs are carried through each successive pair of rolls they are reduced in thickness and increased in length, until they issue from the last pair of rolls in the form of long, narrow plates called "skelp."

In the narrower strips, used for smaller pipes, the width is sufficiently uniform to eliminate trimming with shears, but the skelp for large pipes has to be carefully trimmed to the correct dimensions. In lap-welding, the plate is first laid upon a traveling table and has its edges beveled. It is then heated in a bending furnace and rolled up into the form of a pipe with the beveled edges overlapping. The material is heated and passed through concave welding rolls, between which a ball-shaped mandrel of a diameter equal to the interior of the pipe, is held in position by a long bar. As the skelp passes through the rolls the overlapping edges are squeezed together between the rolls and the mandrel into a perfect weld.

The rough pipe is then passed through sizing rolls and brought to the exact diameter required; then through the cross-straightening rolls, after which the pipe is rolled on a cooling table to prevent warping, and is finally forced by a hydraulic press through the dies of a straightening machine. The ends are then trimmed and threaded, and after being screwed into the couplings, the pipe is given various bending, torsional, flanging and compression tests in a hydraulic machine. If the weld breaks the pipe is scrapped. Lap-welding is now applied to larger pipe up to a maximum length of 15 to 18 ft., and a diameter of 20 in. Test pressures vary from 300 to 3000 lb. per square inch. In the larger sizes the maker's name is rolled into the pipe, and in the smaller sizes it is stenciled upon the pipe. Boiler tubes are tested under the drop hammer by end-on blows.

In butt welding, the edges of the plate are left square. The skelp is heated to the welding point and is then drawn through a bell-shaped die, the diameter of which is a little less than that of the skelp. The pressure thus induced squeezes the edges together and makes a perfect weld. The smaller pipes are generally fitted with screwed flanges and couplings. Nothing is required in the interior of the pipe in butt welding.

The attainment of the proper temperature during the drawing process is vital to the success of the work. The larger pipes must be kept moving during butt welding to prevent sagging. There is a tendency for scale to run to the bottom and cause corrosion in butt-welded pipe. At the works of the National Tube Co. a method of overcoming this trouple has been developed for pipes up to 4 in. in diameter. The pipe is passed through rólls which pull it enough to loosen the scale, which then drops off. This treatment is of great value when a pipe is to be galvanized and has a future outlook, which is worth bearing in mind.

The Exposition's Progress

A part of the main exhibit section of the Panama-Pacific International Exposition to open in San Francisco in 1915, is shown here. The picture was taken from the south side of the grounds. The large groups of buildings clustered on the right lie between the south gardens and an elaborately landscaped marine boulevard on the shores of San Francisco harbor. The exposition lies in a great natural amphitheater encircled on the south, east and west by the hills of San Francisco and the wooded slopes of the Presidio reservation. The picture was taken at a considerable elevation and so does not reveal the great height of the buildings.

The large steel frame seen in the center of the gardens is the dome of the Palace of Horticulture. This dome is 186 ft. high and 152 ft. in diameter; when completed it will be covered with glass and at night colored searchlights will play upon it from within, giving the dome the effect of a gigantic soap bubble, sparkling and iridescent in all the colors of the rainbow.

In the foreground, before the Palace of Horticulture, is a part of the south gardens, which will be marvels of tropical transplanting.

The large group of buildings on the right has eight exhibit palaces, four of which face on San Francisco harbor, the others bordering on the south gardens. The buildings facing the south gardens are, left to right, the Palaces of Education, Liberal Arts, Manufactures, and Varied Industries; the palaces facing the harbor are Food Products, Agriculture, Transportation, and Mines and Metallurgy.

The large white dome from left to right is on the Palace of Education; this dome is 160 ft. in height and 100 ft. in diameter. The next dome, of similar proportions, is on the Palace of Liberal Arts. Next to it may be seen the dome of the Palace of Food Products. The building to the right and prominent in the picture is the Palace of Manufactures, on which the dome has not yet been superimposed. The cross naves in this palace, at the intersection of which the dome will be placed, are 110 ft. high. Then comes the dome of the Palace of Transportation, and at the extreme right appears one corner of the Palace of Varied Industries. In the opening in the center of the group and to the right of the first two domes, will be the Tower of Jewels, which will rise in terraces to a height of 433 ft. The tower will be cleft by an archway 125 ft. high, through which visitors will enter from the main gates into the Court of the Universe.

Thousands of men are at work on the grounds, and the construction is proceeding with unparalleled rapidity. Machinery Hall, with an area of nine acres, is now practically completed. Three buildings are almost finished and all of the palaces will be ready to receive exhibits on July 1.

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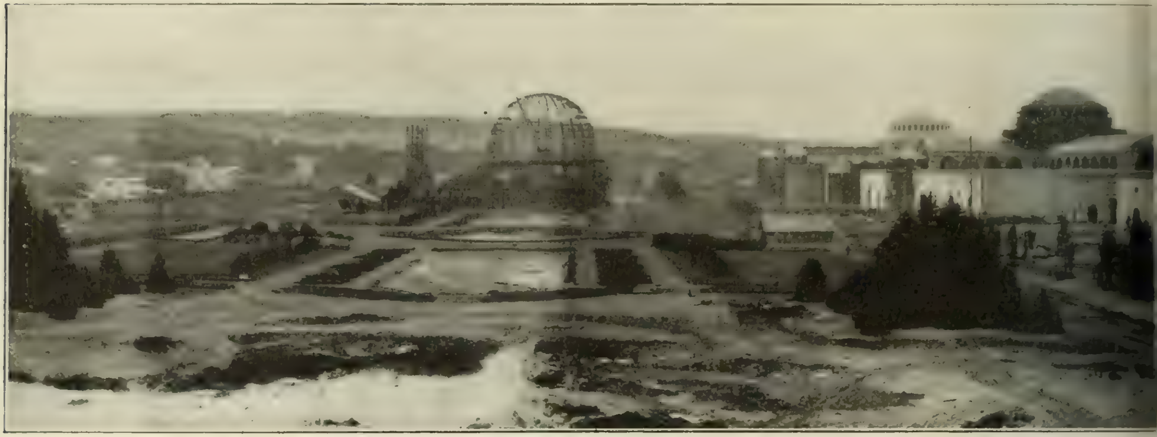
Municipal Electric Plant Completed—The new $75,000 municipal electric-light plant and distributing system of Cedar Falls, Iowa, has been completed. Current is now being furnished for street lights and connections have been made with a number of factories. The new plant will gradually take over the entire electrical service from the Citizens' Gas & Electric Co., whose franchise expired some months ago.



Part of the Main Exhibit Section of the Panama-Paci

Memorial to "Titanic" Engineers Unveiled

The unveiling at Southampton, England, on Apr. 23, of a memorial to the engineers of the "Titanic" was witnessed by 10,000 persons.

The ceremony was performed by Sir Archibald Denny, the Scottish shipbuilder, and an address was delivered by Albert W. Swalm, United States Consul at Southampton.

The memorial is a granite monument, surmounted by a bronze angel bearing a laurel wreath.

Nova Scotia Mine Boiler Explosion

An explosion occurred at the Drummond Collieries at Westville, N. S., Apr. 2, at about 9 a.m., which cost the lives of seven men and seriously injured five others. The boiler was built in 1903 by the Canadian Heine Safety Boiler Co., of Toronto, which has since gone out of existence and never had any connection with the United States company of that name. The pressure for which the boiler was designed was 165 pounds, but the safety valves were set to blow at 100 lb. and were blowing at the time of the accident.

The large loss of life was due to the presence of a number of men in the boiler house eating their morning lunch. The gist of the testimony brought out at the inquest was that the plates were lacking in ductility and that it seemed to be another case of an explosion due to a hidden lap-seam crack, to the dangers of which "Power" has repeatedly drawn attention.

Further details and photographs will appear in an early issue.

Penstock Bursts at Spiers Falls

As a result of the bursting of a penstock at the Troy electric plant at Spiers Falls, near Troy, N. Y., the evening of Apr. 21, the entire city and adjoining towns were plunged into darkness and the trolley lines tied up. The waters of the Hudson River rose and part of the United Traction Co.'s tracks on the west side of the Hudson was said to be inundated. Reports from the north say the woods are full of snow and that the rain and warm weather are resulting in a flood of some magnitude.

Offers $1,000,000 Annually for Los Angeles Aqueduct Power

The electric generating companies of Los Angeles, the Southern California Edison Co., the Los Angeles Gas & Electric Corporation and the Pacific Light & Power Corporation have agreed to buy all of the energy generated by the Los Angeles aqueduct power plants.

In a formal offer the companies agreed to pay the city a wholesale price to be set by the State Railroad Commission amounting to at least a million dollars. This is with the full understanding that the city council will protect the people by fixing a low retail rate. As an alternative the companies have offered to enter into a coöperative arrangement with the city for the public use of their complete distributing systems for five years, the city to make all rates, all contracts with consumers, read all meters, handle all money and collect all bills.

The companies will receive only the sum determined by the State Railroad Commission as equitable. It is pointed out that either of the offers will materially reduce tax burdens and that coöperation between the city and the companies for five years will greatly improve Los Angeles' financial standing.

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Massachusetts "Tech" Buildings Progressing

In the construction of the new buildings of the Massachusetts Institute of Technology on the Cambridge side of the Charles River Basin at Boston, rapid progress is being made. Some 400 men are at work on the site, and the force is being steadily increased. Concrete was first poured for the foundations on Apr. 9. Three piledrivers are at work with a capacity of 300 piles per day, and an extensive lumber yard and construction mill equipment are in use.

The well of the hydraulic laboratory is practically completed and the aëronautical laboratory is ready for service. An experimental span is being erected for the electrical laboratory for transmission investigations, with two steel towers similar to the Big Creek (Calif.) installation, the span being 500 ft. Thesis work by Institute students is being pushed along civil-engineering lines, including tests of full-size concrete beams. Electrical energy for construction service on the ground is being supplied by the Cambridge Electric Light Co., a 90-kw. transformer installation having been erected for present requirements.

The buildings are being erected by the Stone & Webster Engineering Corporation, of Boston.

TERNATIONAL EXPOSITION, TO OPEN IN SAN FRANCISCO IN 1915

NEW PUBLICATIONS

ELEMENTARY MAGNETISM AND ELECTRICITY. By Cyril M. Jansky. Published by the McGraw-Hill Book Co., 239 West Thirty-ninth St., New York, 1914. Size 6x9 inches; 212 pages, illustrated. Price $1.50 net.

This book has been prepared in connection with the extension course of the University of Wisconsin and as such is especially adapted to those who have had some practical experience with electrical machinery, but are unfamiliar with the theory and fundamental principles of operation. The experimental method of presentation is employed, and while it would be advisable if the reader could carry out these experiments which are mostly simple and require only home-made apparatus, still the illustrations and problems are such as will afford a good understanding of the subject without the actual experiments. Briefly, the subjects covered are magnetism, electro-magnetism, electromagnetic induction, the electric current, resistance, induced currents, and electrolysis. Only simple mathematics are employed and the applications are well illustrated with problems.

ENGINEERING AFFAIRS

The motion-picture lecture on the manufacture of pipe from the ore to the finished product, as given by the National Tube Co. in various cities, was delivered in the Y. M. C. A. hall, Newark, N. J., on May 5. Those in attendance were chiefly engineers, plumbers and steam users. Admission was free.

The 14th annual six weeks' summer school of the College of Engineering of the University of Wisconsin will open on June 22. Courses of instruction and laboratory practice are offered in electrical, hydraulic, steam and gas engineering, mechanical drawing, applied mechanics, testing of materials, machine design, shopwork and surveying, in addition to which subjects may be taken in the College of Letters and Science. For bulletin or for further information, address F. E. Turneaure, University of Wisconsin, Madison, Wis.

PERSONALS

E. J. Deckman, for seven years past, the representative of the Hoppes Manufacturing Co., in Pittsburgh, has become district sales manager for the Eynon-Evans Manufacturing Co., for Pittsburgh and vicinity, with an office in the Oliver Building.

W. J. Maxwell, formerly one of the chief operating engineers of the Merchants' Heat & Light Co., Indianapolis, has accepted a position as engineer of the Spy Run power station of the Fort Wayne & Northern Indiana Traction Co.

W. S. Heger has recently been appointed by the Busch-Sulzer Bros.-Diesel Engine Co. as manager of the Pacific Coast sales division, with offices in the Rialto Building, San Francisco. He has the assistance of Hugh S. Jones and W. S. Heger, Jr., as sales representatives. For 25 years Mr. Heger has been selling and installing power-plant equipment on the coast. He established the original Pacific Coast agency of the General Electric Co. in 1889. In 1895 he became the manager in the same territory for the Westinghouse Electric & Manufacturing Co., from which position he resigned after 10 years to become assistant to the president of the Allis-Chalmers Co., later returning to the coast to assume charge of its San Francisco and Los Angeles offices.

NEW EQUIPMENT

ATLANTIC COAST STATES

The A. L. Swett Electric Light & Power Co. is considering an expenditure of $6000 for the improvement of its plant at Medina, N. Y., including the installation of a 150 hp. generator and a water wheel connected to a generator.

The council of Butler, N. J., contemplates the installation of a municipal electric light plant to cost $35,000.

SOUTHERN STATES

Plans are being considered for the installation of a municipal electric-light plant at Flora, Miss.

Plans are being considered for the installation of a municipal electric-light plant at Breaux Bridge, La.

The Russell & Burgess Hardwood Lumber Co., Memphis, Tenn., will purchase new power equipment for its plant, which is being rebuilt after a destructive fire.

The Water & Electric Light Works, of Union City, Tenn., will begin work soon on improvements to amount of $20,000, consisting of addition to building, concrete roof on boiler house, three 200 hp. boilers, smokestack (concrete), 200,000-gal. pump, and 275,000 gal. underground reservoir. C. B. Allen is preparing plans and specifications and will have charge of the work. Plans also include 250 kw. generator and engine, to be installed after boiler and pumping equipment is completed.

A company is being organized for the purpose of constructing an electric light plant in Cadiz, Ky. Stanley White, George Smith and A. P. White, Cadiz, are interested.

The city of Sebree, Ky., will purchase boilers for a waterworks to be installed shortly.

CENTRAL STATES

J. E. Leach is making preliminary arrangements for the installation of an electric-light plant at Cheneyville, Ill.

WEST OF THE MISSISSIPPI

A. L. Peck contemplates the installation of an electric-light plant in Arnolds Park, Iowa.

The Central Iowa Light & Power Co. is preparing to install an electric-light plant in Gowrie, Iowa.

Bonds for $50,000 have been voted for the construction of an electric-light plant at Pratt, S. D.

W. F. Mulaney, Marshall, Minn., will install an electric-light plant in Cottonwood, Minn.

Preparations are being made for the installation of a municipal electric-light plant at Mintare, Neb., to cost $6000.

At a recent election bonds for $20,000 were voted for the installation of a municipal electric-light plant at Parker, S. D.

Bonds for $20,000 have been voted for the construction of a municipal electric-light plant at Manilla, Iowa.

J. B. Sterling and associates are interested in the installation of an electric-light plant at Dayton, Tex.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance.

Positions Open, (Civil Service Examinations), Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen Contract Work) and For Sale, 5 cents a word, minimum charge, $1.00 an insertion.

Miscellaneous (Educational—Books) 10 cents a word, minimum charge $1 50.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. p

POSITIONS OPEN

COMPETENT ENGINEER to run 140-hp. De La Vergne oil engine; one capable to do all repairs; state experience and wages desired. Gifford-Wood Co., Hudson, N. Y.

WANTED, by a large company, an experienced and capable man who thoroughly understands his business, to take charge of a department working about 100 men, making elevator cars and inclosures. P. 211, Power.

Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on or up to the dates given. For detailed information, write the United States Civil Service Commission, Washington, D. C., or other addresses specified.

STEAM ENGINER—$900-$1500; examination May 23; for vacancy at the Capitol heating and power plant; for residents of Wisconsin only; write Wisconsin Civil Service Commission, Madison, Wis.

POSITIONS WANTED

GAS ENGINEER, seven years' experience with gas and oil engines, producers, air compressors, pumps and electric work; best reference; will go any place. P. W. 215, Power.

POSITION WANTED by engineer well versed on steam, electric machinery, a.c. and d.c. Corliss and high-speed engines; good references; Western States preferred. P. W. 210, Power, Chicago.

MECHANICAL ENGINEER, five years' experience erection and maintenance factory and power-plant equipment, building construction, handling of material in bulk and package. P. W. 216, Power.

SENIOR MECHANICAL ENGINEERING STUDENT, 22, wants employment after June 10, 1914; will do anything; lifetime experience in shops of my own; am accustomed to hard work; anything will do. P. W. 212, Power.

LET ME INCREASE YOUR BOILER-ROOM EFFICIENCY; thoroughly experienced in the combustion of fuels and the design and operation of stokers; now holding responsible position with stoker company; age 29. P. W. 213, Power, Chicago.

MECHANICAL ENGINEER, technical graduate, 30, six years' experience, thoroughly familiar with shop methods, four years mechanical engineer and chief draftsman for railroad recently taken over by a larger system; references the best. P. W. 209, Power.

WANTED—To correspond with manufacturer desiring services of master mechanic, having erecting-engineer and machine-shop experience; can handle men acquainted with all latest high-speed machines and boiler appliances. P. W. 208, Power.

SUPERINTENDENT of power of large group of power plants, desires to correspond with employers requiring the services of a high-grade power-plant engineer; thoroughly experienced in all branches, and can deliver results; only a strictly high-grade position, and salary commensurate with same is solicited. P. W. 214, Power.

WANTED

AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

SPECIALTIES—If you recognize the value of approved specialties in an engine and boiler room as a means to higher efficiency; if you believe in this sort of thing to the extent that you think you could sell a well known boiler specialty in your territory for an old-established manufacturer in the power-plant field, write and tell us all about yourself; on receipt of your letter we will outline our proposition in full. W. 33, Power.

MISCELLANEOUS

ASBESTOS SHEET PACKING guaranteed superior; all sizes, any quantity; state requirements extreme prices, permanent supply, samples. "Manufacturer," 634 Temple Court Building, New York.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

FOR SALE

BOILER—350-hp. water tube, used 30 days; insured 200 lb. steam pressure; cost $3500; price, $1500. Duzets & Son, Hu-son Terminal, New York.

DYNAMOS—Two 75-kw. Westinghouse, 125-volt, direct connected Ames automatic engines; $975 each. Duzets & Son, Hudson Terminal, New York.

GENERATORS—Two 75-kw.-Wheeler, 250-volt, direct-connected Harris Fleming engine, with switchboards; $1200 each. Duzets & Son, Hudson Terminal, New York.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

A $10,000, 250-KW., 125-VOLT Fairbanks-Morse generator, direct connected to an American ball angle compound engine, can be had at a bargain; only four years old. Bloomingdale Bros., 3d Ave. and 59th St., New York.

1—1000 KW. FILER & STOWELL; 1—1200 kw. Rice Sargent; 1—600 kw. Allis-Chalmers. Vertical engines complete with generators and condensing plant, etc., and in good operating condition. Call or write for further particulars. Western Electric Co., Purchasing Dept., Hawthorne Station, Chicago, Ill.

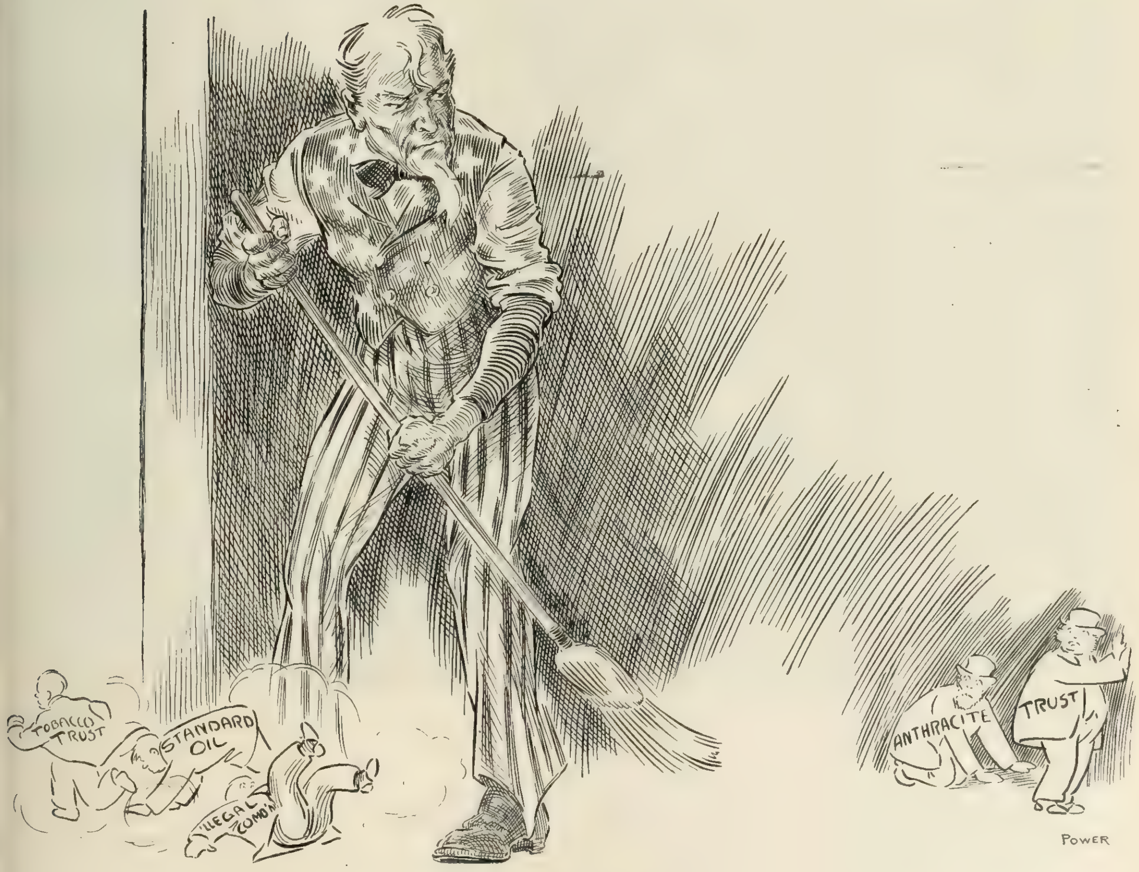
NO. 21 STIRLING BOILERS—Three class A. 280 hp. each; one class A No. 24 Stirling Boiler, 320 hp., with Dorrance shaking grates, complete with fronts, drums, framework, no tubes; best condition, 160 lb. pressure, one year's use; stored ready for inspection or shipment. A. E. Staley Manufacturing Co., Decatur, Ill.

BUCKEYE STEAM ENGINES—Two at bargain prices. One 12"x21" 85 hp., 185 r.p.m., 85 lb. steam pressure; flywheel 6' 0" diam. 22" face. One 11"x18" 70 hp., 200 r.p.m., 85 lb. steam pressure; flywheel 4' 0" diam. 14" face; changed to motor drive. Must move at once. Write today. The W. H. Mullins Co., Dept. C, Salem, Ohio.

CORLISS ENGINES—1100 HP—26&42x48 Vilter Cross Compound Corliss Engine, Belt Wheel 18'. 800 HP.—22&32x42 Allis Corliss Tandem Compound, Right-hand, 18' Belt Wheel, both Engines perfect condition. Have to move immediately so make price; each engine $1050 f.o.b. cars, guaranteed excellent condition. Harold R. Wilson Machinery Co., 413 Pine St., St. Louis.

POWER

Vol. 39 NEW YORK, MAY 12, 1914 No. 19



YOU'RE NEXT

New Equipment for Batavia, Ill., Plant

SYNOPSIS—The addition of a 7500-kw. turbine increases the total capacity to 16,000 kw. Feature of the new installation is the condenser and auxiliaries.

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The Batavia plant, which is about 40 miles southwest of Chicago, furnishes power to the Aurora, Elgin & Chicago R.R. and other traction interests. Current is also supplied for lighting the cities of Elgin, Wheaton, West Chicago and Lombard, and several smaller towns.

Originally, the equipment included four Cooper-Corliss horizontal cross-compound engines connected directly to 1500-kw. three-phase generators. A vacuum of 25 in. was carried on barometric condensers and ten 500-hp. Edge Moor boilers supplied the steam. Late in 1910, a 2500-kw. mixed-pressure turbine was installed and so connected that it could take exhaust steam from either pair of reciprocating units or live steam from the boilers. The station economy was bettered 16 per cent. without adding to the number of boilers, although four more were eventually installed for reserve capacity.

The increasing demand for power made it necessary to again enlarge the plant. Last summer, a 7500-kw., seven-stage horizontal Curtis turbine, driving a 2300-volt, three-phase, 25-cycle generator at 1500 r.p.m., was put in operation. This necessitated the installation of four additional 500-hp. boilers, raising the total capacity to 9000 hp.

The generating unit, shown in Fig. 1, is of standard design, but the condensing equipment embodies some new features recently perfected by the Alberger Pump & Condenser Co. The condenser is of the new "Spiroflo," two-pass type, having 15,000 sq.ft. of 1-in. tube surface and, at 29 in. of vacuum, a capacity to condense 130,000 lb. of steam per hour with 17,600 gal. per min. of 70-deg. cooling water. The arrangement of the condenser is shown in Fig. 2.

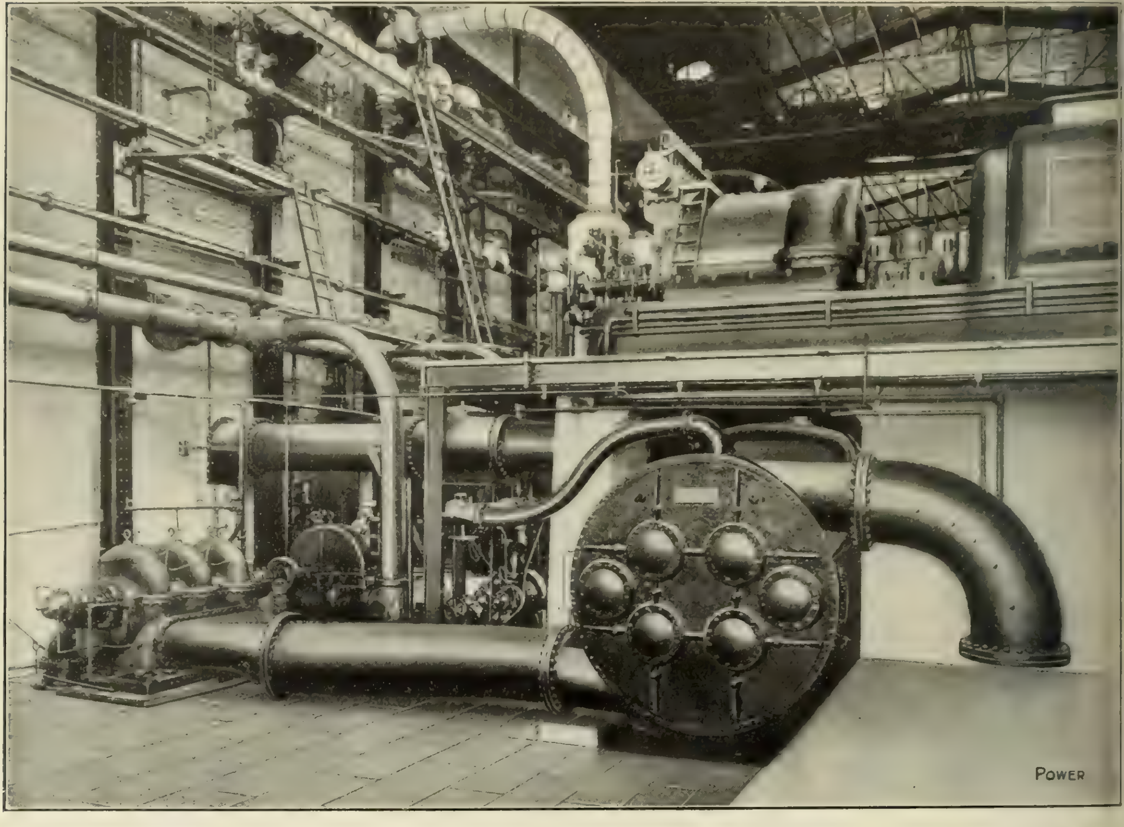


FIG. 1. VIEW OF TURBINE AND SPIROFLO SURFACE CONDENSER AT THE PLANT OF THE AURORA, ELGIN & CHICAGO R.R. CO.

Theoretically, a condenser of triangular cross-section is considered best, as the amount of surface decreases with the steam to be condensed and the air may be efficiently collected and removed at the apex. With this arrangement, practically all of the tube surface is active and, consequently, less surface need be installed. In the condenser under discussion the advantages of a triangular cross-section are secured by the use of a spiral partition or baffle which so divides the surface that the area exposed to the steam is gradually reduced. The air from over the full length of the steam space is collected in the baffle and removed at the two ends. It is cooled on its way through and the water of condensation carried along with the air is removed through water-sealed drains provided on the under side of the baffle.

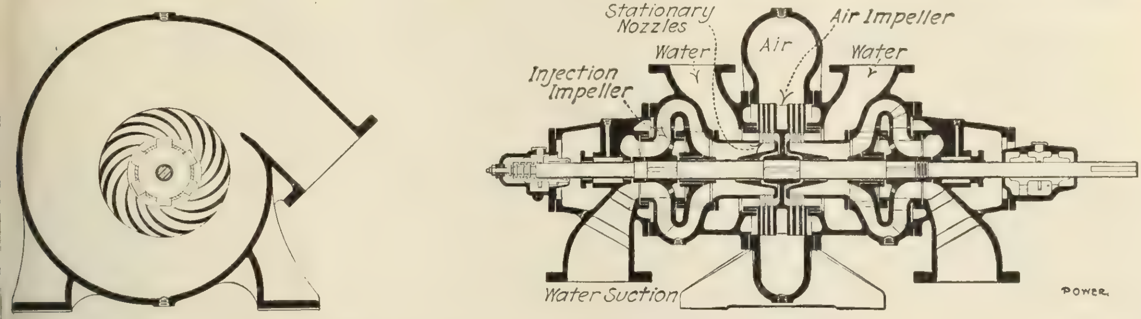
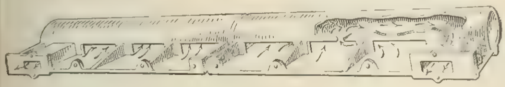


Fig. 3. Details of Hydroflo Dry-Air Pump

From the spiral baffle in the condenser the air is removed by a new type of centrifugal dry-air pump, shown in vertical section in Fig. 3. As is apparent, the pump is provided with an injection impeller on either side of a double air impeller, so that there are two air- and two water-suction openings. The injection impeller lifts the water from the suction supply and gives it an initial pressure which changes into velocity as the water is discharged through stationary nozzles into the air impeller.



PERSPECTIVE VIEW OF SPIRAL BAFFLE AND AIR COOLER

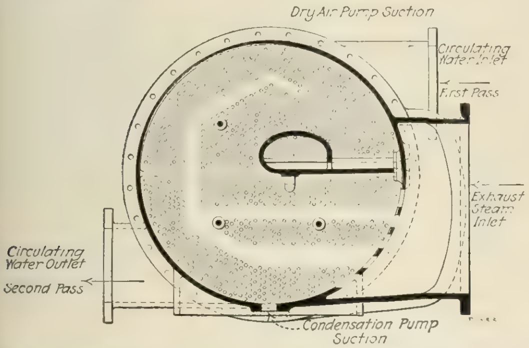


Fig. 2. Perspective View of Spiral Baffle and Air Cooler and End View of the Spiroflo Surface Condenser

Air is admitted between the stationary nozzles and the mpeller so that alternate plugs of water and air are ntroduced into the passages of the impeller and disharged by centrifugal force into the volute casing and hence to the atmosphere. An important feature of the ump is the water impeller. As this creates the initial elocity, the vacuum may be lost and the pump will not ose its suction, so that there is no occasion for priming.

Cooling water for the condenser is drawn from Fox River through a tunnel by a 28-in. tri-impeller turbovolute pump. It is delivered to the condenser on the side opposite the steam inlet and a portion of it passes through the air-cooling tubes in contact with the baffle. Partially heated, the water then enters the tubes of the second pass on the inlet side of the condenser, so that the hottest water comes in contact with the steam at the entrance. Through a second tunnel the water flows back to the river some distance down stream and is discharged at a point just below a dam erected to insure a sufficient supply of water at all seasons.

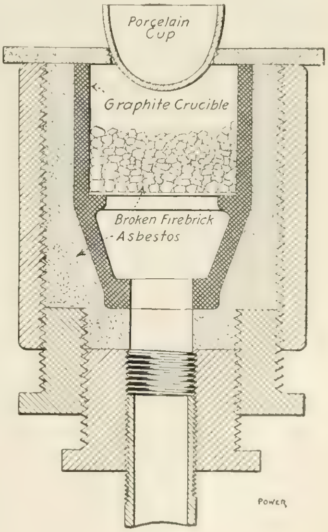
Both the dry-vacuum and circulating pumps are driven by Alberger-Curtis single-stage turbines consisting of one wheel carrying three rows of moving blades and two rows of stationary blades secured to the casing. The former requires a turbine of 10 hp., and a 120-hp. turbine drives the circulating pump. Condensation is removed from the bottom of the condenser by a motor-driven, two-stage, 4-in. centrifugal pump.

⁂

Retort for Burning Coal Samples

Those who have city gas in their engine rooms and test the coal used in their plants will find the little retort herewith illustrated a good one for burning the samples. It is made from a coupling and reducers as a casing to hold a graphite crucible separated by asbestos. Graphite bars as grate bars are laid on lugs on the crucible, and broken firebrick, in pieces a little smaller than a hickory nut, are laid on the grate. A piece of sheet asbestos with a small hole in the center serves as a cover to prevent the rapid radiation of heat and to hold the porcelain cup containing the coal.

The bottom reducer should be small enough to take a $\frac{3}{8}$- or a $\frac{1}{2}$-in. pipe through which a mix-



Retort for Burning Coal Samples

ture of air and gas is led to the bottom of the crucible. The retort works on the surface-combustion principle. When the firebrick reaches a light cherry-red heat no flame is visible, and soon the brick becomes white hot.

This retort was originally made and used by William Freer, power engineer for the American Locomotive Co., at Schenectady, N. Y. The retort is not patented, and individuals are free to make them for themselves.

⁂

Gas Passage in Return-Tubular Boilers*

By Osborn Monnett†

SYNOPSIS—The following discussion applies to the use of the bituminous coals found in the Middle West, more particularly Illinois coals, whose average composition is about as follows: moisture, 8 per cent.; ash, 12 per cent.; volatile matter, 32 per cent.; fixed carbon, 48 per cent.; heat value, 10,900 B.t.u. Lower-grade coals, lignites, etc., found further West, need special consideration and the data given herewith must be varied to suit local conditions, with such fuels. The grate area and arrangement of dampers and breeching are considered.

⁂

Grate Area for Return-Tubular Boilers

The ratio between heating surface and grate surface has an important bearing on the production of smoke, especially in hand-fired units. For hand-fired installations this ratio should not be as large as with mechanical stokers. In Table 1 is a set of dimensions for different sizes of horizontal return-tubular boilers giving the area of heating surface, horsepower and ratio of grate to heating surface. These dimensions are satisfactory for suitably designed hand-fired furnaces. Low ratios for the smaller boilers are employed because the small boiler does not usually get the expert attention required to operate smokelessly with high ratios. With the low ratios, providing liberal grate area, the fires do not have to be cleaned so often and the operating conditions are more nearly those which the ordinary fireman can handle without trouble. With the larger sized units usually installed in the more important plants, the supervision is better, the class of labor is higher and ratios of from 40 to 48 to 1 can safely be employed.

TABLE 1. HORIZONTAL RETURN-TUBULAR BOILER DATA

Size Diam. In.	Size Length Ft.	Dimensions of Grate Width	Dimensions of Grate Length	Grate Area Sq.Ft.	Heating Surface Sq.Ft.	Rated Horse-power	Ratio Heating to Grate Surface
54	14	4	4½	18	628	63	35 to 1
54	16	4½	4½	20¼	718	72	25 to 1
60	16	5	5	25	896	90	36 to 1
60	18	5½	5	27½	1008	101	38 to 1
60	16	5½	5½	30¼	1043	104	37 to 1
66	18	5½	5½	30¼	1173	117	39 to 1
72	16	5½	6	33	1327	133	40 to 1
72	18	6	6	36	1493	149	41 to 1
78	18	6	6½	39	1843	184	41½ to 1
78	20	6½	6½	42¼	2047	205	48 to 1
84	18	6	7	42	1937	194	46 to 1
84	20	6½	7	45½	2153	215	47 to 1

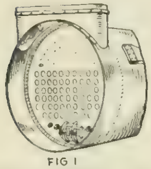


FIG 1
COMMON THOUGH FAULTY FORM OF UPTAKE

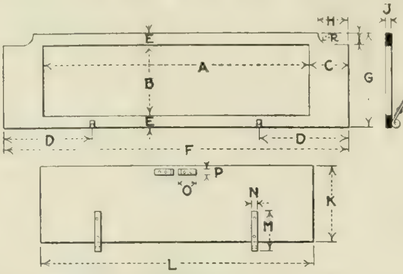


FIG:2- DESIGN FOR IDEAL HORIZONTAL RETURN TUBULAR BOILER DAMPER

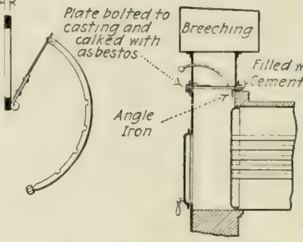


FIG.3
IDEAL DAMPER AND UPTAKE ARRANGEMENT

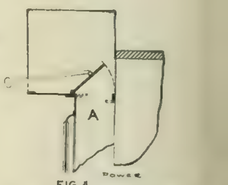


FIG.4
DAMPER AND BREECHING CONNECTION FOR LIMITED HEAD ROOM

Showing Faults and Proper Arrangements of Uptake and Damper for Return-Tubular Boilers

Size of Gas Passage at Rear

In setting return-tubular boilers, many builders restrict the gas passage at the back head, which is detrimental to good operation. Table 2 shows dimensions that can be recommended for this space.

Damper Design

The tube area, fixed by the manufacturer, is generally sufficient to allow the gases to pass freely to the stack while working at ordinary commercial capacities, consequently, this need not be discussed.

Restriction at the damper reduces the amount of coal which can be burned per unit of time and, therefore, is a limitation on capacity. Further, it tends to shorten the life of the brickwork of the furnace and setting because if the gases cannot pass off freely the heat will be "bottled" and the brickwork will melt.

A common form of uptake is shown in Fig. 1. This gives a long and narrow opening which is not as good, even though it is of the required area, as one more nearly square. The damper of a return-tubular boiler should provide a free opening 25 per cent. in excess of the total tube area. Fig. 2 shows the design of an ideal damper and the dimensions for dampers for different sizes of boiler are given in Table 3.

TABLE 2. DISTANCE FROM BACK HEAD OF BOILER TO COMBUSTION CHAMBER WALL

Size of Boiler	Diameter, in..	54	54	60	60	66	66	72	72	78	78	84	84
	Length, ft....	14	16	16	18	16	18	16	18	18	20	18	20
Back head to wall, in....		26	26	28	28	30	30	32	32	34	34	36	36

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*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, city of Chicago.

This type may be applied to continental or marine types of boiler, also to the Hawkes, Kroeschell combination and Lyons boilers. The object of this design is to avoid the long and narrow opening as far as possible and obtain a free passageway for the gases to the stack.

Fig. 3 shows another design of damper which eliminates the damper plate and gives a maximum opening into the breeching. Fig. 4 shows a good damper and breeching connection where head room is limited. The dotted lines indicate how this damper was originally installed. Draft readings taken before the change was made showed 0.52 in. over the damper and 0.26 in. below at point *A*, indicating a direct loss of 0.26 in. After the change the draft at point *A* was increased to 0.49 in. and a free direct passage to the breeching was obtained.

TABLE 3. DIMENSIONS IN INCHES FOR DAMPER SHOWN IN FIG. 2

Diameter of Boiler, In.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
36	24	10	8	12	3	40	16	5	2	7/8	13	25	6¾	1	3	1	2
42	36	10	7½	13	3	46	16	5	2	7/8	13	37	6¾	1	3	1	2
48	38	10	7	14	3	52	16	5	2	7/8	11	39	6¾	1	3	1	2
54	44	12	6½	14½	2	57	16	5	2	7/8	13	45	6¾	1	3	1	2
60	49	15	6½	11¾	1½	62	18	5	2½	7/8	16	50	6¾	1	3	1	2½
66	54	15	6½	14¼	1½	67	18	5	2¼	7/8	16	55	6¾	1	3	1	2¼
72	60	18	6½	16	1½	73	21	5	2¼	7/8	19	61	6¾	1	3	1	2¼

BREECHINGS

Breechings should be laid out with the run to the stack as short and direct as possible, and wherever a turn is necessary, it should be a long sweep bend. Sharp right-angle turns in the breeching should be avoided and likewise sudden changes in cross-section. The connection to the stack should also be in an easy sweep to avoid a drop in draft at this point. Fig. 5 is a good model to follow with horizontal tubular boilers. It shows in detail a breeching serving five 150-hp. boilers and the stack connection designed for maximum draft efficiency.

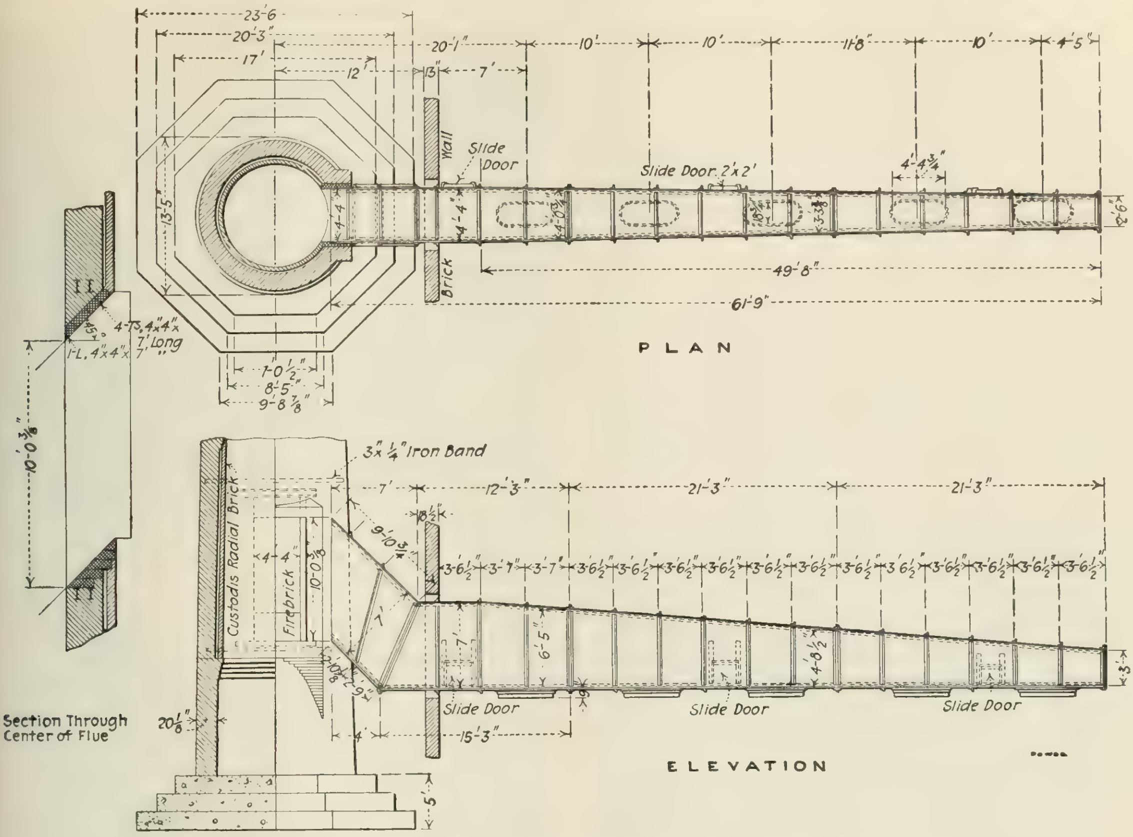

FIG. 5. MODEL BREECHING AND STACK CONNECTION FOR RETURN-TUBULAR BOILERS

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Large Elevator Installation—The 23 passenger elevators in the Continental & Commercial Bank Building, Chicago, are known as the gearless traction electric type. This type possesses some features which differ considerably from those of the geared type; for example, the hoisting cables are not wound on a drum, but drive over a sheave which is bolted directly to the armature spider of the motor by means of a flange, integral with the spider. The necessary tension in the wire cables to secure tractive force between the driving sheave and the hoisting cable is secured by passing the cables partially around the traction driving sheave and then around an idler leading sheave, forming a complete loop around both sheaves. The car and the counterweight are suspended from opposite ends of the cable, thus avoiding the use of intermediate gearing. The motors used in this elevator system are of the slow-speed shunt-wound type, with a capacity of 35 hp. The normal capacity of each elevator is 2500 lb., lifted at a speed of 500 ft. per minute. To insure safety the motor is equipped with a governor which regulates the motor speed regardless of the load. At the bottom of each shaft there is an oil-cushion buffer which brings the car to a stop, being regulated by the escape of oil from one chamber of the buffer to another.—"Engineering and Contracting."

New Turbine Power Plant of the Louisville Railway Company--II

By W. O. Rogers

SYNOPSIS—The boiler room is arranged for future extension, and has eight 500-hp. water-tube boilers. There will ultimately be 16 additional units and a second chimney 225 ft. high. Fuel is elevated to the coal bunker above the boilers in 2-ton hand, push cars, by means of two 6000 lb. capacity platform elevators. Ashes are handled in the same manner and are discharged into an ash hopper from which they are loaded into railway cars.

*

The initial boiler installation in the High Street Station of the Louisville Railway Co. consists of eight 500-hp. water-tube units, Fig. 9. Provision has been made for eight additional boilers of the same size. The steam pressure is 180 lb. superheated 125 deg. at the normal rating of the boilers, which have parallel drums. The tubes are 14 in. high and 18 in. wide. Each boiler furnace is equipped with an engine- or motor-driven chain-grate stoker with a grate 9 ft. 6 in. wide by 12 ft. 3 in. long, a total of 153 sq.ft., or 1 sq.ft. of grate surface for each 3.26 boiler horsepower. The boiler settings are much higher than usually employed, the front end of the tubes being 6 ft. above the grates. This gives a large combustion chamber in which to burn Kentucky pea and slack coal, which will be used.

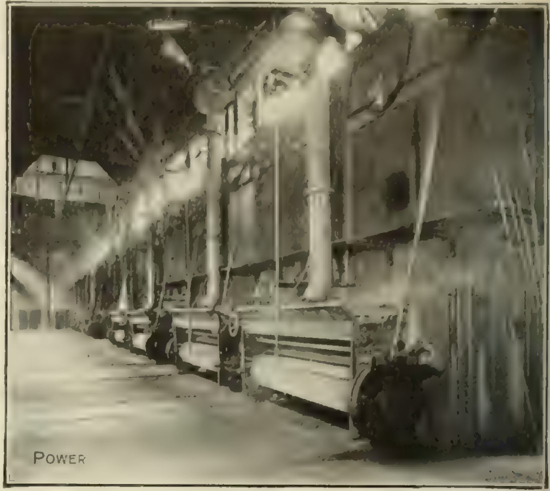


Fig. 9. Eight 500-Hp. Water-Tube Boilers

These boilers are served by a red, radial brick chimney, 255 ft. high and 13 ft. inside diameter at the top, and built on a concrete foundation which goes down to bed rock. The stack has sufficient area to provide a square foot for each 36.25 boiler horsepower and was designed to serve the eight boilers installed in two batteries on each side of it. Foundations for a second stack and for a second row of eight boilers have been provided on the opposite side of the room. The second chimney will be 255 ft. high and 18 ft. in diameter, and will ultimately serve 16 additional boilers.

The present stack, with six boilers in service, gives a draft of 1.2 in. of water. Over the front of the grates and at the main breeching with the damper open, the draft is 0.45 in. of water. A preliminary test of the

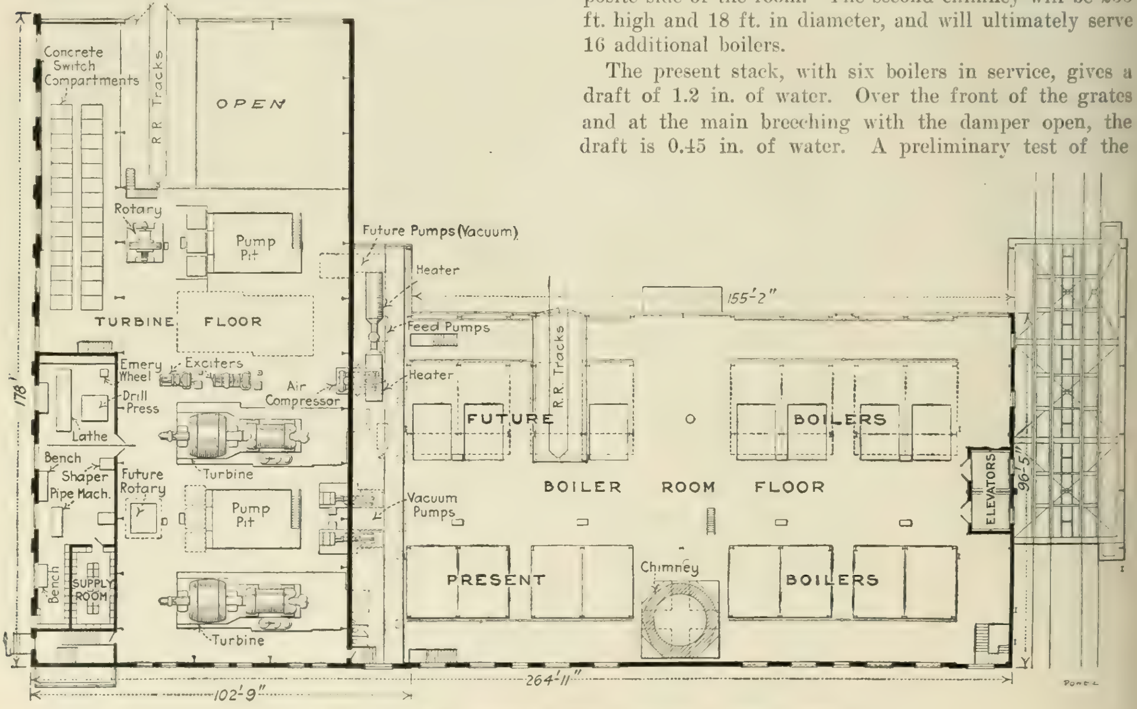


Fig. 10. Plan of the New Turbine Power Plant

boiler and station efficiency during the second month of operation, before all of the steam pipes were covered and while some steam was being used for drying-out purposes, gave a coal consumption of 2.975 lb. per kw.-hr. with 12.5 per cent. ash. The coal tested was approximately 12,000 B.t.u. dry. Figs. 10 and 11 are plan and elevation views of the plant.

COAL AND ASH HANDLING

All coal is received from the steam railroad on two side tracks, which run over three concrete track hoppers at the outside end of the boiler house. From the hoppers the coal is loaded by gravity into two-ton, hand-push steel cars, Fig. 12, which are wheeled onto either of two electrically operated platform elevators, each with a capacity of 6000 lb. The loaded car is hoisted to a level with the industrial track above the coal bin which runs from the elevator shaft over the coal bunkers, and the cars may be pushed to any desired point for dumping. The elevators are designed to run at 100 ft. per min. One is driven by a 550-volt, direct-current motor, the other by a 440-volt, three-phase alternating-current motor; each is of 30 hp. capacity.

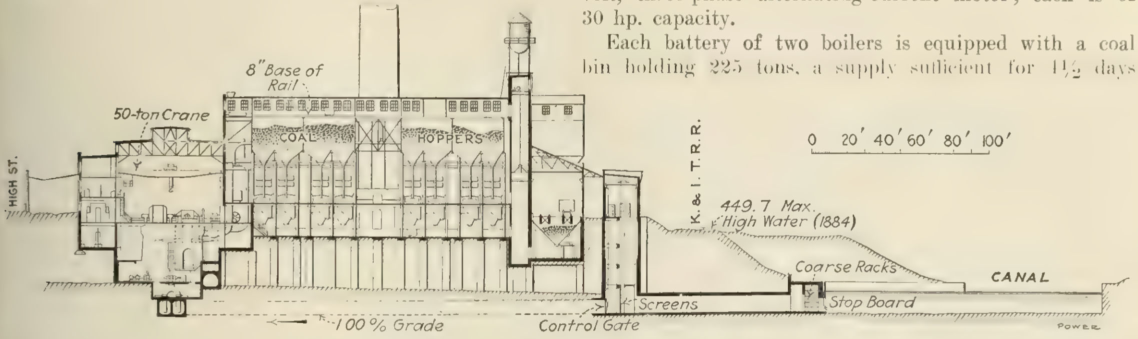


FIG. 11. ELEVATION OF THE HIGH STREET POWER STATION

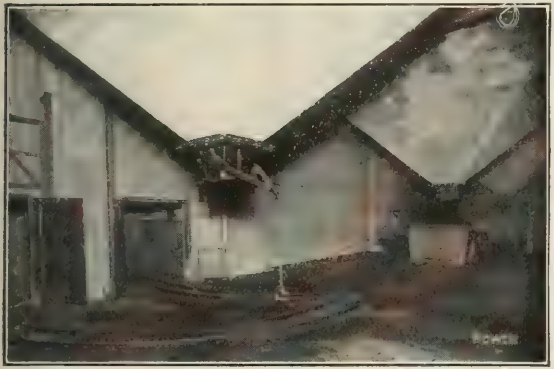


FIG. 12. ROOM BELOW TRACK HOPPERS FROM WHICH COAL IS LOADED INTO PUSH CARS

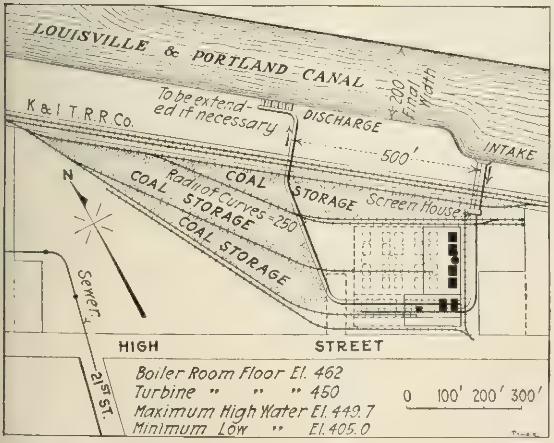


FIG. 13. SHOWING COAL STORAGE OUTSIDE THE POWER PLANT

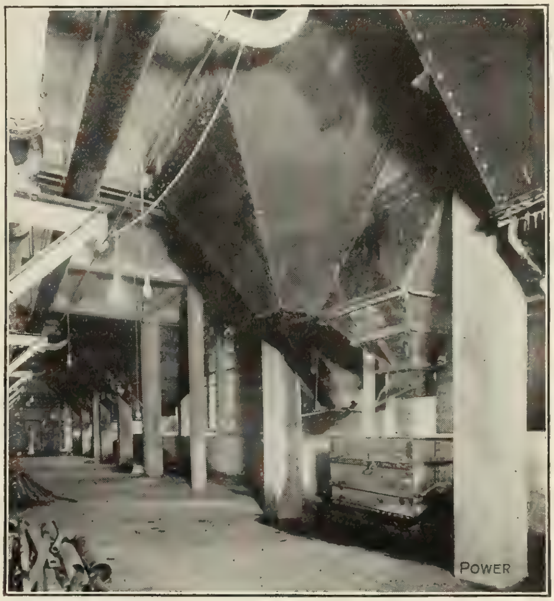


FIG. 14. COAL AND ASH HOPPERS AND ASH CAR IN BOILER-ROOM BASEMENT

Each battery of two boilers is equipped with a coal bin holding 225 tons, a supply sufficient for 1½ days under ordinary operation. The bin of this size is a precautionary measure against a shortage of coal during extreme high-water periods, when the railroad tracks are submerged. The coal-storage capacity of the yard, Fig. 13, is limited only by the height to which the coal may be piled. The side tracks, which are about 4000 ft. long, are capable of storing 90 loaded cars, or about two days' fuel supply.

The ashes drop from the furnace grates into one of two steel ash hoppers, lined with firebrick, and are dumped into push cars, Fig. 14, on an industrial track which passes underneath. The other hopper catches siftings from the grates, which are discharged into a car and returned to the coal bunkers. The loaded ash cars are elevated to a steel firebrick lined ash hopper installed over the coal-unloading hoppers, outside the boiler house. By this arrangement, after the coal has been unloaded, the same car may be filled with ash from the ash hopper overhead. This method of handling coal and ash, it is estimated, will show an overall saving of approximately 20 per cent. as compared with the continuous-conveyor systems.

PIPING SYSTEM

There is one main steam header installed over the front of the boilers and at right angles to the turbine room. The header varies in size from 12 to 16 in. and is connected to a cross-header at the end of the boiler room, running parallel to the turbine room. From this cross-header steam is taken to the turbines through two 12-in. long-radius bends. Two 10-in. long-radius bends take steam to an auxiliary header in the basement of the turbine room, from which all auxiliaries are fed.

When additional boilers are installed, a ring system of steam piping is contemplated which will encircle the boiler room and permit cutting out of service any battery of boilers. All the headers and valves are of cast steel and the boilers are safeguarded with automatic cut-off valves.

All steam piping 4 in. in size and over is designed to carry 200 lb. pressure and 125 deg. superheat, and is covered with a layer of 1-in. fire felt, followed by a molded layer of 85 per cent. magnesia, 2 in. thick and covered with 8-oz. duck. All the piping, including 1-in. and smaller, is insulated with 1-in. thick fire felt and covered with duck. The cold-water piping, where condensation might cause trouble, is covered with 1-in. anti-sweat covering, and exhaust steam and hot-water pipes with 1-in. asbestos air-cell covering.

The building was erected according to architectural plans made by D. X. Murphy & Bro., of Louisville. They were drawn from designs laid down by F. H. Miller, superintendent of motive power of the company, to whom the writer is indebted for photographs and drawings, the former being unobtainable when the plant was inspected.

⁂

Progress of the Smoke-Abatement Movement in Europe

By JOHN C. KERSHAW

SYNOPSIS—Outlining what has recently been done in Europe in attacking the smoke evil. Hamburg has a smoke-prevention society made up of manufacturers, the membership being 434. This society's engineering staff makes tests, inspections and alterations in the members' plants for the purpose of stopping smoke production and of increasing the efficiency. Finland is active in smoke abatement. Twenty-four English and Scotch cities are making soot observations with standardized apparatus and methods. Hamburg has joined this movement. Technical educational authorities in many English and Scotch cities have included classes for engineers and firemen in their curricula. Glasgow a leader in this work.

⁂

The problems of smoke abatement are intimately associated with those of boiler efficiency and of fuel economy. This connection between smoke and inefficiency is today quite clearly recognized. Although a strong case for smoke abatement can be made out on hygienic grounds, it will always be the economic argument that is the most convincing to the man who is actually producing smoke. Prove to him that a cleaner chimney top means a smaller coal bill, and he will become an ardent and willing helper in a campaign against black smoke; whereas in the absence of this proof he will remain an indifferent witness, or energetic opposer.

This connection between smoke abatement and improved fuel economy has been clearly and usefully demonstrated in Germany and Finland, by the work of the two smoke-abatement societies established in Hamburg and in Helsingfors, the latter society being an offshoot of the former. The Hamburg parent society—the Verein für Feuerungsbetrieb und Rauchbekämpfung—was founded in 1902. According to its last report, it has 473 members and 1593 steam boilers or other heating appliances on its register; and it is of interest to note that nearly all the members are manufacturers or factory owners who have joined for the benefits that can be obtained in the more scientific control of their boilers. The society is a voluntary association of large consumers of fuel bound together simply by the common desire to obtain the highest possible efficiency and the minimum of smoke. Each annual report contains numberless examples of the improvement in efficiency that results when the engineering staff has taken charge of the plant.

When the skilled engineers and firemen of the "Verein" took control of the plant I have in mind, they changed the conditions of working as regards draft, admission of secondary air and the thickness of the fuel bed. Burning less coal, they evaporated more water and raised the efficiency of the two boilers from 58.6 to 70 per cent.; this is equal to a reduction in the coal bill of 20 per cent. The reports are full of equally striking examples of the economies gained by skilled supervision of boilers, combined with the work of properly trained and paid firemen. It is strange that this method of attaining such striking and valuable results by the voluntary association of fuel users has not been more widely adopted. In the hope that some American cities may follow Hamburg and Helsingfors, a few notes on the organization of the Hamburg society are given:

The work is controlled by a committee of from six to nine members, elected annually from the rank and file, at the general meeting. The technical and scientific work is undertaken by the staff of experts retained by the society. At the date of the last report this staff consisted of a chief engineer, three assistant engineers, five instructors for firemen, and two clerks, while for special steam-raising and other trials, additional assistance had been employed. The chief engineer attends the committee meetings and takes part in the discussions relating to the work. The funds are drawn from three sources: 1. From the annual subscriptions of its members. 2. From payment for special work and reports for its members. 3. From payments for outside work.

The society is thus entirely self-supporting, and its success is dependent upon the value of the return it makes to its members for their contributions and fees. It is, therefore, gratifying to note that the membership shows steady growth.

The objects are the attainment of the highest possible efficiency from the heating and boiler plants of the members, with the least possible emission of smoke. To this end, regular examination of these plants and of the methods of working them are undertaken by the engineering staff, and suggestions are made for improvements when such are required. The education and control of the firemen in their duties are also undertaken by the firemen instructors on the staff. Comparative tests of fuel, and tests of smoke prevention and other appliances, are also carried out by the expert staff, and the results are circulated among the members. Members can demand that boilers or heating plants shall be regularly inspected, and that their working shall be tested and reported on at least three times a year. They have also the right to consult the chief engineer of the society regarding improvements and alterations in design and operation.

Further details of organization and rules may be found in a paper contributed by the writer to the London Smoke Abatement Conference of 1905.

Turning to the progress of the smoke abatement in the United Kingdom, the most notable events of the past year have been:

1. The introduction into the House of Commons of a bill to amend and extend the existing laws against smoke emission. 2. The inauguration of soot-gage observations by 24 of the larger cities and towns of the country, on the lines of those carried out by the *Lancet* in 1910-1911. 3. The continuation of the educational classes for firemen and engineers in London, Glasgow, Liverpool, Manchester and many other large cities.

The Smoke Abatement Bill, which was introduced into the House of Commons on Apr. 30, 1913, has for its object the extension of the powers of the local authorities and of the local government board in relation to the nuisance caused by the improper emission of smoke.

Section 1 makes it incumbent upon the owner, occupant, or user of a furnace to have it so constructed that it will consume its own smoke, and the emission of smoke or grit from such furnace or its chimney is constituted a nuisance. At the same time the local government board is given powers to make special exemptions where it is impracticable to avoid making smoke in carrying on a business, but such "power to exempt" is limited to ten years from the passing of the act, and the exemption must be renewed every two years.

Section 3 authorizes the local government board to appoint local smoke-abatement authorities in those areas in which the local sanitary authorities are failing to carry out their duties as to smoke abatement. In London, the London County Council is made the local smoke-abatement authority.

This bill was reintroduced into the House of Lords in March, 1913, by Lord Newton, and was only withdrawn on the promise of the government to appoint a commission of experts to report on the whole subject of smoke, and to indicate the lines upon which further legislation is desirable.

Under Section 4, local inspectors may be appointed by the local authority, subject to certain requirements as to experience and to the control of the local government board.

By Section 5 the local government board is given the right to inspect the records of offenses in order to see if the local authority is properly carrying out its duties and subject to such obligation being satisfied, the local government board may pay not more than half the salary of local smoke inspectors by way of grant in aid. The same section requires the central authorities themselves to appoint government smoke inspectors, and gives such inspectors power to prosecute in cases where the local authority has failed to do so.

SOOT AND DUST OBSERVATIONS

At the International Exhibition of Smoke Abatement Appliances and the conference on the black-smoke problem held in London in March, 1912, a committee was appointed to draw up specifications for a standard apparatus and a method for measuring the extent and character of the air pollution in cities and towns. Numerous meetings of this committee were held in London in 1912-1913 under the presidency of Dr. Norman Shaw, chief of the Government Meteorological Office, and eventually a type of apparatus and method was selected, based on that used for the *Lancet* observations in London in 1910-1911, with certain modifications suggested by experience.

The health authorities of 20 English and Scotch towns and of several of the London boroughs have agreed to join in this work of recording the character and amount of atmospheric impurity. The following towns have joined: Aberdeen, Ayr, Birmingham, Coatbridge, Exeter, Glasgow, Greenock, Hull, Liverpool, Leicester, Leith, London, Malvern, Manchester, Newcastle-on-Tyne, Oldham, Paisley, Plymouth, Sheffield, Stirling, Wishaw and York. Hamburg is also to commence observations with the standard method and apparatus, thus giving the movement an international character.

EDUCATIONAL WORK IN ENGLISH CITIES

The classes for firemen and engineers started in many cities are being carried on with increasing success, and they appear to meet a real need. It is hoped in time to create a standard of merit and efficiency and to issue certificates to successful members.

It is gratifying to note that the technical education authorities of many large towns and cities are now including classes for firemen and boiler engineers in their curricula. So far, Glasgow has been the most successful in conducting these classes, which are carried on during the winter months at several different centers in the workingclass district, and are under the charge of the smoke inspectors of the municipality. Between 100 and 200 firemen have been enrolled each winter in these classes at Glasgow since they were initiated four years ago, and it is now proposed to start a class for the more advanced students who have satisfactorily passed through the elementary course of instruction. Glasgow also ar-ranges a course of public lectures each winter for the more educated part of the community.

Reference must be made to the increase in recent years in the number of gas- and electrical heating appliances employed for domestic purposes, especially in London and the larger towns, where coal is comparatively dear and gas is cheap. The records of the gas and electric-supply companies prove how rapidly the domestic consumer is availing himself of these substitutes for coal, and there is reason to hope that before the first quarter of the twentieth century has passed away, gas and electricity will have largely replaced raw coal as a source of heat in the English household.

Europe has had a year of progress.

⁂

The Kapp Phase Advancer

By Arthur H. Allen

SYNOPSIS—By means of three small direct-current motors connected in circuit with the rotor of an induction motor, an e.m.f. is produced in opposition to that produced by the slip of the rotor and the power factor is raised to unity or above.

⁂

Considerable attention has been devoted lately in England and on the Continent to the problem of phase advancing, with a view to improving the power factor of alternating-current circuits, especially those having induction motors. A machine invented for this purpose by Prof. Gisbert Kapp, a well known pioneer in electrical engineering, has recently been installed in connection with a 330-hp. motor at a cement works near Middlesbrough, England. The motor is supplied with power at 2750 volts, 40 cycles, and runs at 400 r.p.m., the power factor at half load being 0.76, and at full load 0.87.

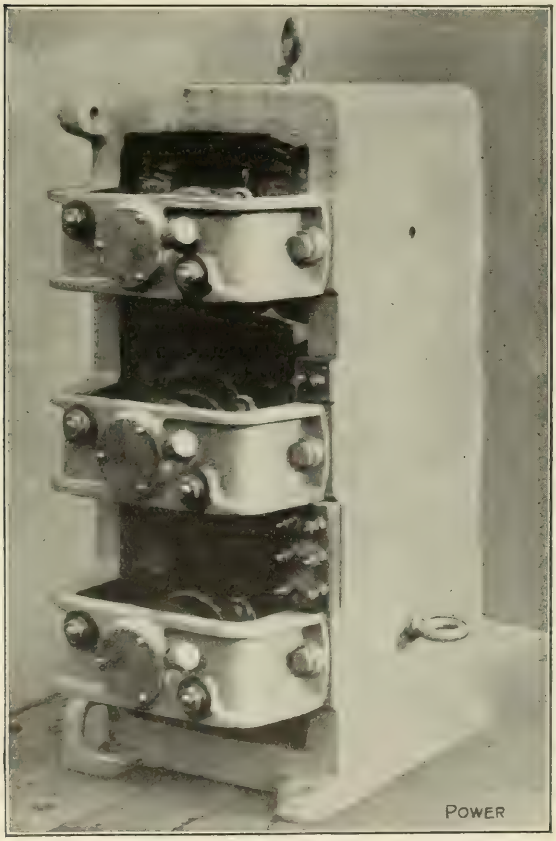


Fig. 1. Assembled View of Kapp Phase Advancer

The phase advancer, or "vibrator," Fig. 1, is a small machine, with three ordinary direct-current armatures running in two-pole fields, which are separately excited with direct current. The armatures are only 4 in. in diameter, and at full load, when the motor has a slip of 2.45 per cent., or about one cycle per second, the armatures reverse their direction of rotation every half second, making about 3½ revolutions in each direction. Connections of the machines are shown in Fig. 2, from which it will be seen that the three armatures are connected in mesh to the slip rings of the rotor winding, and are traversed by the currents flowing in that winding.

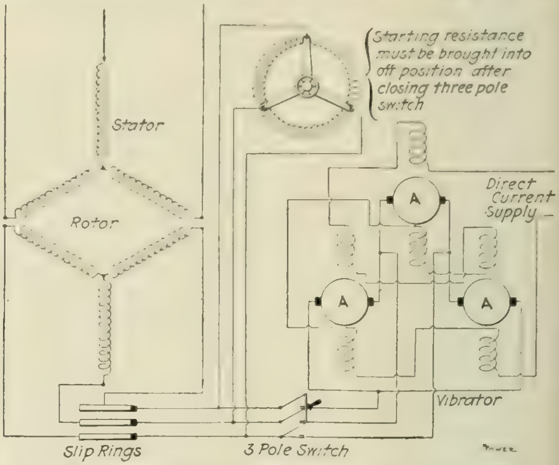

Starting resistance must be brought into off position after closing three pole switch
Stator
Rotor
A
A
A
Direct Current Supply
Vibrator
Slip Rings
3 Pole Switch
Power

Fig. 2. Connections between Motor and Phase Advancer

Reversals of this current cause the reversals of rotation mentioned, but, owing to the inertia of the armatures, the latter lag in phase behind the rotor currents, so that when the current in an armature is approaching its maximum, the armature is coming to rest. Thus the commutator is almost stationary when the current is a maximum, and is moving most rapidly when the current is zero, conditions which are favorable to sparkless operation. The rotation of the armature induces an e.m.f. which is opposed to the e.m.f. of self-induction in the rotor winding, and is greater than the latter by an amount sufficient to supply, through the resistance of the rotor, the necessary current to produce the magnetic field of the motor. With normal excitation of the vibrator, no magnetizing current flows in the stator windings of the motor, and consequently the latter operates with a power factor of unity. If the excitation of the vibrator be increased above this value, the extra voltage induced in the armature will produce in the rotor windings a magnetizing current greater than normal, so that a leading current will be induced in the stator windings, thus helping to improve the power factor of other motors on the same circuit.

The effect of the vibrator is shown by the curve in Fig. 3; at half load the power factor was brought up to 0.99 leading, and at full load to 0.96 leading. The power used for excitation was only 50 watts. Obviously, the power factor could have been made unity if desired, at either half or full load, by reducing the excitation.

The vibrator works equally well when the machine with which it is connected is running either as a motor or as a generator, without any change of connections, a property which enables it to be used with motors driving winding engines or locomotives, giving complete compensation under all conditions. If a fault should occur, the vibrator could be left in circuit with the motor, although out of action, as it would not affect the working of the motor, behaving, in fact, as a short-circuit on the slip rings. It should not, of course, be connected to the slip rings until the motor is running at full speed, and it is easy to provide interlocking gears to prevent the motor being started in this condition. The use of the vibrator also improves the operating conditions by considerably increasing the overload capacity and pull-out torque of the motor. The machine illustrated was built by Sandycroft, Limited, at its works near Chester, England, and is the first of its kind to be put into commercial use.

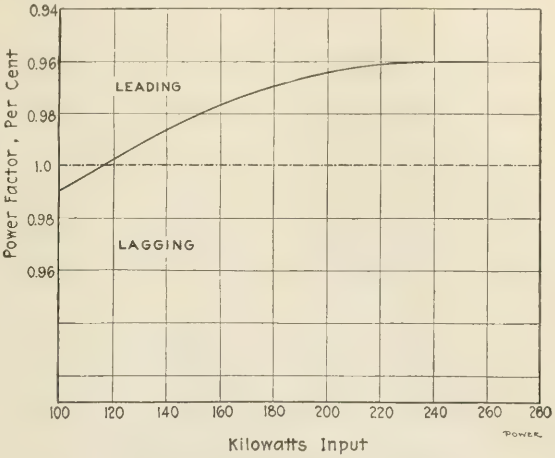


FIG. 3. POWER FACTOR CURVE OF 330-HP. MOTOR WITH KAPP PHASE ADVANCER

* * *

Emergency Repairs in the Early Days

By R. A. Cultra

How we do like to relate our experiences in the plants of long ago, especially where no spare parts, packing or hardly anything else was at hand in case of need. The usual tools were an old dilapidated oil can and a broken or badly battered monkey-wrench. Of course, the engineer was expected to bring a hammer and a cold chisel with him, and other tools if he had them.

It is true, the owners were not fussy about keeping such plants up to the best condition, and much less than fussy when the engineer worked nights, Sundays and holidays without extra pay, on repairs which could have been done in a few hours with proper material and tools.

In one place I put in a piece of pipe 3 in. in diameter and 5 ft. long, and the largest wrench in the plant was an 18-in. Stilson. A rope was wound around the pipe, some rosin put under it, and the ends tied together, forming a loop. Then the end of a piece of 2x4 in. timber was put through the loop and across the pipe. By pulling around the pipe, the rope would grip and turn the pipe. By this means, the joint was so tightly made up that a 3-ft. chain tongs and the combined efforts of two men were required to start the joint six months later.

Mr. Bedore, referring to page 491, Apr. 7, 1914, is not the only one who has made a pump piston out of wood; I have. In my case, it was a boiler-feed pump and there was no spare pump or injector in the plant. The pump had but little head clearance and a bolt from the suction valve, going down into the water cylinder toward the steam end, had broken the piston, which was made of two follower plates with an expansion ring between. A piece of hard wood was turned up $\frac{1}{16}$ in. smaller than the bore of the cylinder and put on the rod with a washer each side. The wood expanded enough to fill the cylinder, but did not bind. It ran nearly a month before a new piston was put on. Wood was selected which did not expand much, and the piston was made enough smaller than the bore of the cylinder to allow for expansion.

On one occasion, Jerry Perkins, the engineer over in the sawmill, having no sheet rubber, came over to get a piece of pasteboard box to pack the steam-chest cover of his engine. His pump valves had worn down as well; one had broken and the pump was out of service. Having no new valves, one was turned up out of lignumvitæ—some hard wood!—and Jerry put it in.

As a reward (?), the boss said he did not see why Jerry needed to buy pump valves when he could make them out of wood. Jerry got no more new valves. It was some plant! What with the flanges packed with pasteboard, the valve stems with hemp twine, the piston rod with rope, and the manhole gasket put in with hemp rope and white lead.

Jerry kept things quite tight at that, but he certainly had to work to do it!

* * *

First Use of the Panama Electric Towing Locomotives was made on Apr. 1, at Gatun Works. Locomotives 641, 642, 643 and 644 towed the launch "Balboa," clapet "No. 1," and a scow through the west flight from Gatun Lake to the Atlantic entrance channel. Clapet and scow were lashed together alongside, but the scow leading by half a length. The low freeboards gave as unfavorable inclination to the towing lines as probably ever will be secured in operation. Passage was completed in 1 hr. 17 min. which is only two minutes more than schedule fixed for operation. Extra lines were carried by laborers, but were not needed.

Will Quizz, Jr.

SYNOPSIS—Will waxes indignant at the electrical dictionary on the subject of the direction of rotation when a generator is converted into a motor. Chief Teller explains the subject.

*

"Good morning, chief! Last night that book of yours that asks itself questions and then answers them, tried to tell me that if a generator was connected up as a motor, and took current from the busbar, it would run in the opposite direction to that which it did to produce current as a generator."

"Well, what else did it say, Will?"

"Say! It didn't say any more, because I simply shut it up and wouldn't let it stuff me. It may talk to itself that way, but not to me, because anyone knows better than that. Don't you remember over in the old plant that when the belt broke, No. 2 machine would keep on running in the same direction until the switch was pulled out?"

"Let's see, Will, those old machines were straight shunt, weren't they?"

"Yes, but what has that got to do with it?"

"Suppose we ask the book. But first do you remember that little arc machine we used temporarily as a motor when we were changing over; which way did that run?"

"Come to think of it, we had to reverse the leads to the brushes to get that one to run the way we expected it to."

"Yes, here it is in the book. Just as you said, the shunt machine rotated in the same direction, because the fields are in parallel with the armature and the arc or series machine rotated in the opposite direction, because the fields were in series."

"Well, it goes on to say that, of course, a compound-wound machine will rotate in one direction or the other according as its shunt or series winding preponderates, or they may just balance when there will be no motion at all. That makes it clear why machines will act differently, and why engineers have experiences which do not seem to tally."

"This book, Will, does not go into lengthy details in answering, but is good to refer to as the old Scotchman said of a dictionary, 'The stories are verra good, but verra short.' "

* *

Transmission of Power by Manila Rope

By Reginald Trautschold

SYNOPSIS—Charts and formulas for figuring the power transmitted by rope drive, the sizes of sheaves, etc. Also the characteristics and advantages of rope drive are discussed.

*

Records show that rope manufactured from the fiber of palms was used in Egypt long before the days of Christianity. Such ropes were found in the tombs of Beni-Hassan (3000 B.C.) and on the walls of these same tombs are illustrations depicting the preparation of hemp. Carvings found in tombs in Thebes represent the process of making rope from thongs of leather, about 1600 B.C., and Assyrian sculptures of about 50 years later show gigantic hauling operations performed with rope. These records are of particular interest as indicative of the steps through which rope manufacture passed in the early ages.

Of the flexible ropes suitable for power transmission, a manila rope is just as strong as a solid steel bar, weight for weight, though only about 11½ per cent. as strong per equal cross-section. Leather, on the other hand, is only about 5 per cent. as strong as a steel bar of equal cross-section and less than 40 per cent. as strong per equal weight of material.

The relative efficiency of manila rope and leather belting for the transmission of power is not directly proportional to their respective strengths, however, as the internal construction of a hemp rope and a strip of leather differ greatly and are affected very differently by wear. Manila fibers, from which the rope is manufactured are usually from 8 to 10 ft. in length, are composed of elongated cells that possess great strength longitudinally but are comparatively weak transversely. Leather, on the other hand, is about equally strong in any direction so that the wear on such a belt is mostly external. In a manila rope the wear is largely internal, the elongated fiber cells being crushed together when passing around a sheave and breaking up into short pieces. A worn-out manila rope, as far as its strength is concerned, may have the outward appearance of an excellent rope while internally its construction is but a mass of short, broken particles. The allowable working stress of a good leather belt is customarily taken as 320 lb. per sq.in., or about $\frac{1}{10}$ its tensile strength. In the course of a year or so a manila rope will lose about 50 per cent. of its original strength, after which the weakening becomes more gradual. Under such conditions it is safe to figure on an allowable working stress of about 288 lb. per sq.in. or $\frac{1}{32}$ its tensile strength.

The cross-section of a manila rope closely approaches a circle, and an allowable working stress of 288 lb. per sq.in. is equivalent to a maximum allowable tension of 225 d^2 (pounds), where d is the diameter of rope in inches.

The influences exerted against the productive force in a rope drive are those of centrifugal force, the tension required in the slack side to keep the rope from slipping and the air resistance, the latter negligible at low speeds but appreciable at very high speeds. The difference between the productive force and the sum of the unproductive forces, corrected for mechanical inefficiency of the sheaves, etc., will then give the useful power that can be transmitted by a rope drive.

Fig. 1 represents the distribution and consumption of power by various sizes of manila rope traveling at different speeds. The upper curves show the theoretical power that can be transmitted, corrected for the loss due to the centrifugal force, and the shaded areas, the consumption of power by air resistance and mechanical friction. Theoretically, the maximum horsepower transmitted by a rope drive would be when the rope travels at a speed of about a mile a minute (88 ft. per sec.) but the best actual speed is somewhat less than this, being about 75 ft. per sec. or 4500 ft. per min. In Fig. 2 is shown the net power that can be advantageously transmitted at various speeds. Expressed as a formula

$$Hp. = (0.26 - 0.00001073v^2 - 0.00048v)\ vd^2 \quad (1)$$

where v is the velocity of the rope in feet per second and d the diameter of the rope in inches. The results from this formula agree closely with the curves in Fig. 2, which were plotted from actual conditions.

The curves in Fig. 2 and also the horsepower derived from the use of the formula depend on a 180-deg. wrap of rope on the driving sheave and upon the angle of the sheave groove. Cases arise where it is impossible to obtain a satisfactory wrap of the rope about the driving sheave, the apparent arc of contact being less than 180 leg. In such cases, the power transmitted by the driving heave would be reduced by about one-third of 1 per nt. for each degree of contact less than 180. As a correction factor this may be expressed as follows:

$$B = 100 - 0.34\ (180 - A) \quad (2)$$

here B is the percentage of the maximum power transmitted and A is the arc of contact on the driving sheave. he power-transmitting capacity of drives having an aprent arc of contact over 180 deg. does not increase at e same rate, the effective arc of contact being about 165 g. for an apparent wrap of 180 deg. Increasing the apparent wrap much over 180 deg. simply necessitates such a degree of snubbing that any gain in power-transmitting capacity is lost in increased friction and unproductive consumption of energy, except in the case of very short drives. Should greater accuracy be required, the correction factor may be taken from Fig. 3, which is plotted from experimental data and shows the effect of the arc of contact on power transmission by a sheave with properly proportioned grooves.

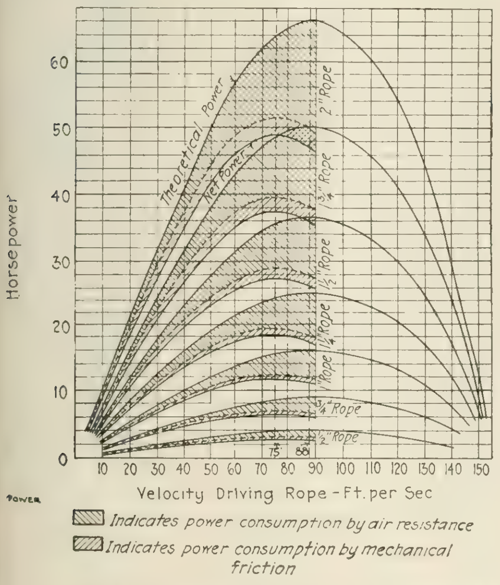


FIG. 1. POWER CONSUMED IN AIR RESISTANCE AND MECHANICAL FRICTION

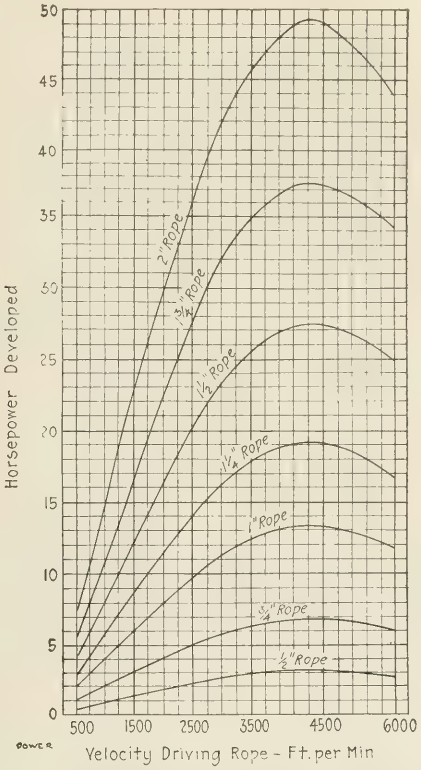


FIG. 2. VELOCITY VERSUS NET HORSEPOWER

The horsepower transmitted by any rope drive, depending upon the difference in tension between the taut and slack sides of the rope, permits the calculation of the tension required in the slack side. Expressed as a formula

$$T' = 75d^2 + 0.0000017d^2V^2 \quad (3)$$

where T' represents the tension on the slack side in pounds when transmitting the full load; d is the diameter of the rope in inches and V the velocity of the rope in feet per minute. Table 1 gives the advisable tension to put on the slack rope, from data derived from actual working conditions. The results from the formula and the data of the table agree very closely.

TABLE I. TENSION ON SLACK ROPE IN POUNDS WHEN TRANSMITTING FULL LOAD

Diameter of Rope Inches	Speed of Rope—Ft. per Min. 1000	2000	3000	4000	5000
½	20	22	24	28	33
⅝	30	32	35	41	48
¾	42	45	50	57	66
⅞	58	61	68	77	90
1	75	80	89	101	117
1⅛	95	102	113	130	150
1¼	118	126	139	159	183
1⅜	142	153	168	191	220
1½	169	180	200	227	260
1⅝	198	211	235	267	305
1¾	230	245	273	309	358
1⅞	263	282	314	356	409
2	300	320	355	407	468

Knowing the tension on the taut and slack sides of a rope drive, it is possible to calculate closely the sag between supporting sheaves. Obviously, the sag on the slack side is considerably more than on the taut side, but

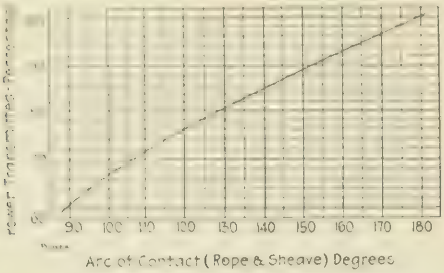


FIG. 3. ARC OF CONTACT VERSUS POWER TRANSMITTED

the driving side is usually the lower side so that more clearance is available for the slack rope.

$$S = \frac{0.3\,L^2}{1800} \tag{4}$$

$$S' = \frac{0.3\,L^2}{600 + 0.0000136\,V^2} \tag{5}$$

where L is the distance between supporting sheaves in feet; V the velocity of the rope in feet per minute; S the sag on the driving side and S' the sag on the slack side.

Formulas (4) and (5) give the proper sag in the driving and slack ropes respectively when the drive is transmitting its full proper power capacity. Table 2 gives similar data obtained from observations under working conditions.

TABLE 2. SAG OF ROPE BETWEEN SHEAVES WHEN TRANSMITTING FULL CAPACITY

Distance Between Sheaves, Ft.	Taut Side All Speeds Ft.	In.	Slack Side Running at the Following Ft. per Min. 1000 Ft.	In	2000 Ft	In.	3000 Ft.	In.	4000 Ft.	In.	5000 Ft.	In.
25	0	1¾		3¾		3½		3		2¾		2½
50	0	5½	1	4	1	3	1	1		11½		9¾
75	1	0⅛	2	11	2	9	2	6	2	2	1	10
100	1	9	5	1	4	9	4	4	3	10	3	3
125	2	10	7	11	7	5	6	9	6	0	5	2
150	4	0	11	3	10	7	9	8	8	8	7	6

In taking up the design of equipment necessary for manila rope transmission of power, the most important consideration is the diameter of the sheaves, as it is upon this that the life of an installation and hence its economic value largely depend. The life of a manila rope is not only dependent upon the degree of bend but also on the number of bends that must be made. The most efficient minimum diameter of sheave for a manila rope traveling at 4500 ft. per min. is about 40 times the diameter of the rope. At such speed, the requirements of the rope are at a maximum and may, therefore, be considered as equal to 100 per cent. At any lower speed the requirements are proportional so that the allowable working stress can be altered accordingly. For instance, at half this speed the rope could be subjected to a working stress nearly twice as great, and as the number of bends that the rope makes is dependent upon both the speed of the rope and the diameter of the sheave, the diameter of the latter need be but half as great as at the higher speed.

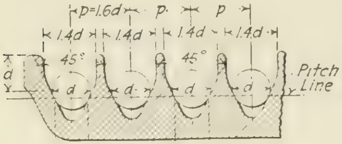


FIG. 4. DRIVING AND DRIVEN SHEAVES

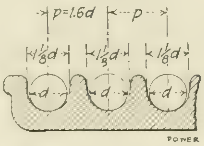


FIG. 5. IDLER AND GUIDE SHEAVE

Not only are manila ropes used for the transmission of power, but they are also used for hoisting operations where the maximum speed attained under load rarely exceeds 1000 or 1500 ft. per min. and for tackle operations where the rope speed does not exceed 900 ft. per min. Taking the efficient rope speed and diameter of sheave for power transmission as constant, the correct diameter for sheaves for hoisting purposes would be from 9 to 13 times the diameter of the rope, and for tackle operations eight times that of the rope. The relative allowable loads are for transmission purposes, $\frac{1}{32}$ of the ultimate strength of the rope; for hoisting, [illegible]/32 to [illegible]/36, and for tackle operations $\frac{5}{32}$ of the ultimate strength of the rope. For hoisting there is quite a noticeable variation in the diameter of the sheaves as recommended by different authorities, due to the great variation of rope speeds that may be considered as standard maximums; hence, it is advisable to limit the allowable working load for hoisting operations, the rope being subjected to greatly fluctuating loads to about two-thirds that which would be advisable under more uniform and constant conditions of service. Table 3 contains data on allowable working loads and sheave diameters that are considered good practice.

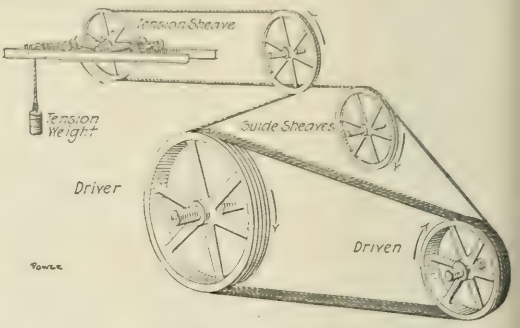


FIG. 6. TENSION TAKEN FROM DRIVING SHEAVE

Of almost as much importance as correct sheave diameter is that of proper design of rope grooves. The grooves for both driving and driven sheaves should possess enough gripping power to prevent slippage, but this grip should not be so great as to cause the rope to wedge. Experience has shown that the 45-deg., V-shaped groove is the most suitable, the width of the groove on the pitch line being slightly more than three-quarters (0.76736) the diameter of the rope, with a reasonable clearance between the un-

TABLE 3. WORKING LOADS AND SHEAVE DIAMETERS FOR MANILA ROPE

Diameter of Rope In.	Ultimate Strength Lb.	Allowable Working Loads, Lb. Transmission of Power	Hoisting	Tackle	Minimum Diameter of Sheaves, In. Transmission of Power	Hoisting	Tackle
½	1,800	56	95	280	20	8	4
⅝	2,810	86	160	430	25	9	5
¾	4,050	126	252	630	30	10	6
⅞	5,510	172	365	860	35	11	7
1	7,200	225	500	1125	40	12	8
1⅛	9,110	285	657	1425	45	13	9
1¼	11,250	351	835	1755	50	14	10
1⅜	13,600	425	1040	2125	55	15	11
1½	16,200	506	1267	2530	60	16	12
1⅝	19,000	595	1514	2975	65	17	13
1¾	22,000	688	1780	3440	70	18	14
1⅞	25,300	790	1974	3950	75	20	15
2	28,800	900	2000	4500	80	24	16

der side of the rope and the bottom of the groove; see Fig. 4. Grooves flatter than 45 deg. are apt to permit slippage when subjected to varying loads or overloads, while grooves with sharper angles are apt to wedge the rope unduly. Theoretically, the flanges of the grooves need not extend much past the center of the rope, but the possibility of the rope riding up the side of the groove or of increasing in diameter from some cause, makes it poor practice not to have the flanges extend to at least the top of the rope and preferably a short distance beyond the rope. Idler sheaves require grooves that simply support the rope and guide it without any grip; see Fig. 5.

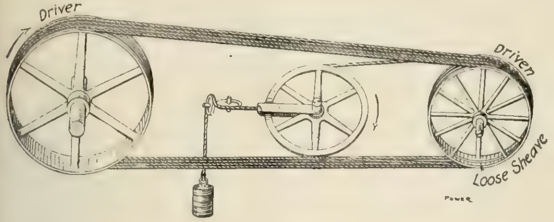
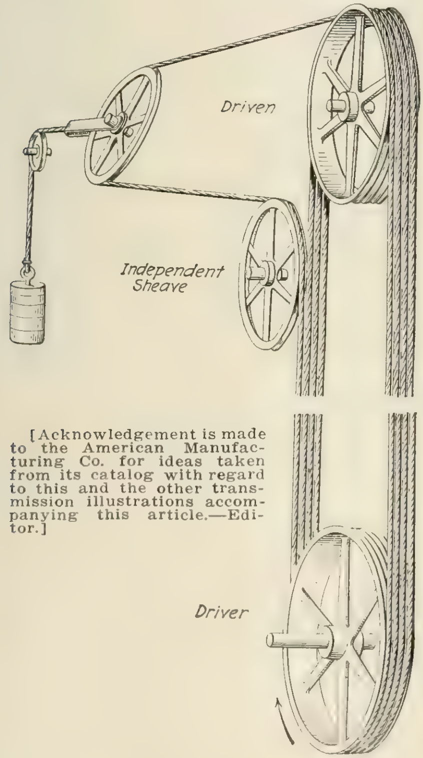


FIG. 7. TENSION TAKEN FROM DRIVEN SHEAVE

One rope being inadequate to transmit large powers, a number of ropes have to be employed in most cases. This has led to the development of two distinct systems of rope drive, the multiple or "English" system and the continuous or "American" system, both of which have points of advantage so that the choice of system is largely a matter of personal preference and local conditions.



[Acknowledgement is made to the American Manufacturing Co. for ideas taken from its catalog with regard to this and the other transmission illustrations accompanying this article.—Editor.]

FIG. 8. VERTICAL DRIVE, TENSION TAKEN FROM DRIVEN SHEAVE

The multiple system is the simpler, consisting of independent endless ropes running side by side in the grooves of the sheaves, the ropes always bending in the same direction. Each rope in this system is an independent drive in itself and should one break the remaining ones can transmit almost as much power without overloading, so that the broken rope may be replaced at a convenient opportunity. In installations where the power from the main generating unit has to be distributed to several floors or to several independent sheaves, this system is particularly adaptable, as groups of ropes may be led from the driving sheave to any desired point. The main disadvantage of the system is that each rope being an independent unit, the tension in both the taut and slack sides should be about the same for all the ropes. As the various ropes may not stretch equally or be equally durable, more or less continual adjustment of tension is necessary that they may all do their equal share of the work. However, this fault is not as serious as has generally been supposed, the effective arc of contact between the rope and sheave not varying to any great extent, although the apparent arc of contact may be quite noticeable. The multiple system of rope drive is the cheaper of the two to install and has the longer life of rope because it always bends in the same direction.

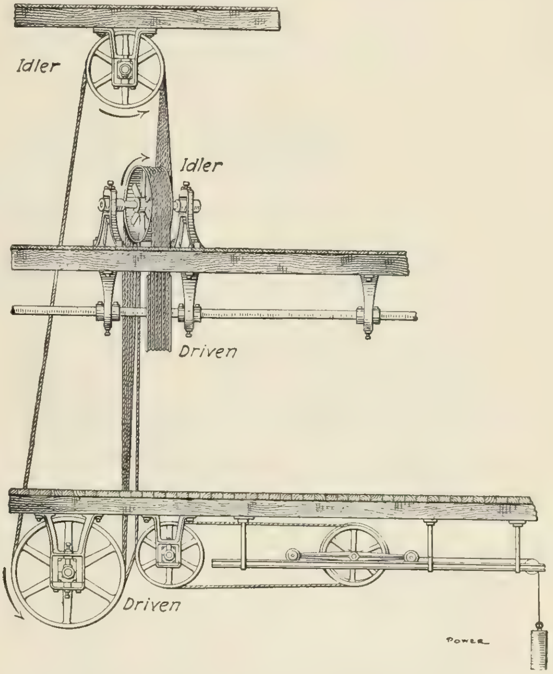


FIG. 9. QUARTER-TURN DRIVE, TENSION TAKEN FROM DRIVING SHEAVE

The continuous system consists of but one endless rope wrapped about the driving and driven sheaves, the different wraps of rope occupying adjacent grooves. The rope from the inner groove of one sheave must be delivered to the outer groove of the other by passing about an intermediate sheave that transfers the rope from the inner-end plane of one sheave to the outer-end plane of the other. The exception to this rule is when the transfer of rope is made from the inner to the outer, or *vice versa,* grooves of the driven pulley. The transfer sheave is usually mounted on a tension carriage so arranged as to travel back and forth, producing uniform tension throughout the rope and automatically regulating the slack that may occur from stretch, varying load, etc. The continuous system, more than the multiple system, is adaptable to quarter-turn drives and installations in which the driving and driven sheaves lie in planes oblique to one another, and to complicated transmission installations. Its main and only serious drawback is that should the rope break at any point the whole system is crippled; besides it is more expensive to install than the multiple system. Typical examples of rope drives of the continuous type are shown in Figs. 6 to 9.

The advantages of rope drive may be summed up as follows:

1. The distance over which power may be transmitted is far in excess of that by belts, chains or gearing. Distances up to 150 or even 200 ft. can be spanned without the necessity of intermediate sheaves and if these are used, the distance can be made much greater.

2. The amount of power that can be transmitted is limited only by the number of ropes employed, installations transmitting up to 5000 hp. from one prime mover being in operation.

3. Compared with belting, a rope drive is much more compact and requires less space, the width of a rope sheave is from one-third to one-half less than the width of a belt pulley for transmitting the same power.

4. Rope drives are noiseless if the bearings are properly lubricated, the flexibility and lubrication of the ropes producing their silent running and the air gaps between the ropes preventing any great atmospheric disturbance.

5. Precise alignment of the shafting is not essential in direct drives of any length and drives may take sudden and marked changes of direction if properly placed guide sheaves are employed.

6. Very little slippage occurs in properly installed rope drives, tending to a maximum conservation of energy.

7. Cheapness as compared with belt drives.

⁂

Selecting a Pump

By Walter Webster

SYNOPSIS—The computations and considerations by which a volute type of pump was selected from the information submitted by several manufacturers.

⁂

A line of artesian wells supplying a tower tank with water through the medium of a triplex plunger pump yields a maximum of 268 gal. per min. Due to the installation of additional manufacturing equipment, a maximum of 675 gal. per min. was required. Test wells proved that no more water was available from that source; city water was considered, but its high cost eliminated the possibility of its use. A near-by river, however, was available, and while it alone could have supplied the requirements, for certain manufacturing processes the well water was preferable. Therefore, it was proposed that the river supply merely the deficiency.

Automatic means requiring minimum attention for maintaining a sufficient quantity of water in the tank was essential. Hence the problem: What was the best method of transferring this water to the tank, operating automatically and utilizing the existing power for the lowest initial maintenance and operation costs in relation to the highest efficiency obtainable?

After consulting a number of catalogs and interviewing several pump salesmen, a volute centrifugal pump was decided upon, since this type seemed best adapted to handling large quantities of water under the conditions stated. Having determined this, the known factors were:

1. Type of pump—volute centrifugal.
2. Head at which pump was to operate at maximum efficiency—80 ft.
3. Length of discharge pipe—610 ft.
4. Capacity—700 gal. per min.
5. Power available—alternating current at 550 volts, 60 cycles, three-phase.

The capacity determined on could supply a trifle more than the maximum requirements; this was to insure unfailing service in case the well pump was under repairs. If the volute pump were crippled city water would be available.

The accompanying diagram illustrates the general operating conditions of the system, from which we had carefully calculated that the pump would operate for a period of 4½ min. approximately five times an hour, and since the demand was not so great at night as during the day, it would operate for a total of six hours out of every twenty-four.

As a result of the conferences with the several pump salesmen, notes were made of characteristics to consider and proposals were requested, submitted and tabulated as follows:

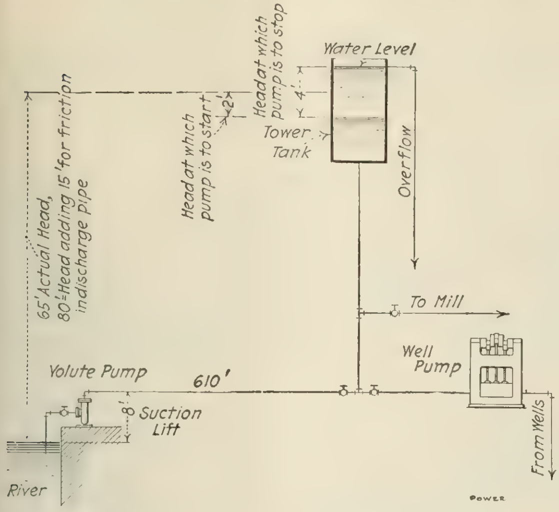
PARTICULARS OF DIRECT-CONNECTED VOLUTE CENTRIFUGAL PUMP

Make of Pump	A	B	C	D	Remarks
Stage	Single	Single	Single	Single	
Suction lift	8′-0″	8′-0″	8′-0″	8′-0″	
Length of discharge pipe	610′	610′	610′	610′	Friction equal to 15′-0″ head
Head in ft. at which maximum eff. is required	80′	80′	80′	80′	
Gal. per min.	700	700	700	700	
Size of suction	8″	8″	6″	6″	
Size of discharge	6″	6″	6″	6″	
R.p.m.	1740	1740	1740	1740	
Casing (type)	split hor.	split hor.	split hor	split hor	
Brake hp.	21.74	20.48	21.09	19.63	b.hp. $=\frac{700\times8.33\times80}{33,000\times\text{eff.}}$
Maximum power under any condition b.hp.	23	21	22	21	
Pump efficiency	65	69	67	72	
Size of motor, hp	25	20	20	20	
Coupling	flex.	flex.	flex.	flex.	
Total weight	2900	2680	2450	2200	
Total cost including electrical apparatus	\$ 588.50	\$ 576	\$ 524	\$ 573	
F.o.b. our factory	yes	yes	yes	yes	
Delivery	30 days	45	45	60	

Other points considered in the selection were

1.—Availability of stuffing box.
2.—Liabilities to leaks.
3.—Wearing parts renewable without renewing expensive parts.
4.—Protection against corrosion.

Maintenance and depreciation charges were considered equal in each make of pump and the choice depended on operating charges, which was decided on a basis of efficiency, the cost of a kilowatt-hour being 2¼c. As a result of these tabulations, pump A was eliminated at the beginning, due to its high initial cost and lower efficiency. This left the choice between pumps B, C and D. Comparing pumps B and C and converting the brake horsepower into kilowatt-hours for the six hours per day:


Head at which pump is to stop
Water Level
4'
2'
Head at which pump is to start
Tower Tank
Overflow
65' Actual Head, 80' Head adding 15' for friction in discharge pipe
To Mill
Well Pump
Volute Pump
610'
8' Suction Lift
From Wells
River
POWER

ARRANGEMENT OF PUMPS AND PIPING

for pump B

$$\textit{kilowatt-hours} = \frac{20.48 \times 746 \times 6}{1000} = 91.66$$

and 91.66 × 0.0225 = \$2.062 = cost of power for one day's operation of pump B.

For pump C

$$\textit{kilowatt-hours} = \frac{21.09 \times 746 \times 6}{1000} = 94.38$$

and 94.38 × 0.0225 = \$2.123 = cost of power for one day's operation of pump C. Then, \$2.123 — \$2.062 = \$0.061 = Saving in cost of power per day of pump B over pump C.

Cost of pump B = \$576
Cost of pump C = 524

Excess cost of pump B = \$ 52

Then, \$52 ÷ \$0.061 = 852 days pump B would have to operate to pay the excess cost over pump C.

Thus it would require nearly three years of 300 working days each for pump B to pay for its increased cost over pump C, not considering the interest on the additional investment. Therefore, pump B was eliminated, leaving pumps C and D for final choice. Following the same method for pump D,

$$\textit{kilowatt-hours} = \frac{19.63 \times 746 \times 6}{1000} = 87.86$$

and \$87.86 × 0.0225 = \$1.976 = cost of power for one day's operation of pump D. Then, \$2.123 — \$1.976 = \$0.147 saving in cost of power per day of pump D over pump C.

Cost of pump D = \$573
Cost of pump C = 524

Excess cost of pump D = \$ 49

\$49 ÷ \$0.147 = 333 days pump D would have to operate to pay the excess cost over pump C.

In this instance it was shown that pump D would pay the excess cost over pump C in a little over one year of 300 working days, and would accomplish a saving every year thereafter of \$44.10. Should the pump operate more than six hours per day, which was not at all unlikely, the saving would be correspondingly increased. The choice of the pump was, therefore, conceded to pump D.

In the selection of the electrical apparatus no attempt was made to compare different makes. The reason for this was that since the pump was to operate automatically, reliability was the important factor, and it had been decided to specify apparatus manufactured by a reliable concern that had given us satisfaction in previous installations.

A lesson to learn from the foregoing is, that it is not always the lowest-priced apparatus which is the best to purchase, and unless it is investigated thoroughly, the engineer is likely to use poor judgment in the selection of the apparatus best suited for his particular proposition.

*

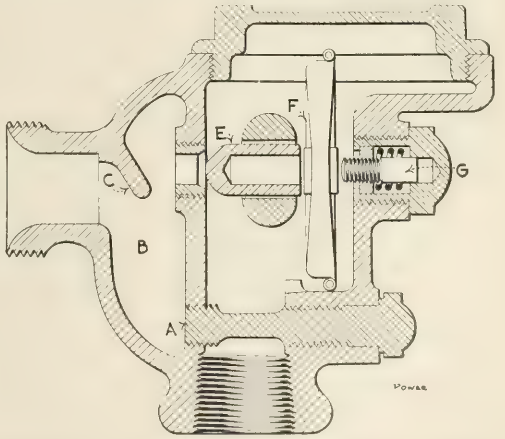
New Monash Thermostatic Valve

The principal enemy of a thermostatic valve is the amount of dirt and sediment in the system; another objectionable feature is the trouble, due to the collapse or rupture of the thermostatic diaphragm.

One feature of the Monash thermostatic valve, illustrated herewith, is that, when steam comes to the valve chamber, the valve *E* closes without any steam pressure coming in contact with the thermostatic member. The diaphragm, being relieved of all pressure caused by steam remaining in the valve case, cannot rupture.

Dirt or sediment cannot pass through the valve opening into the expansion chamber, because there is an ample dirt pocket in advance of the valve seat, with a deflector *C* to throw this dirt and sediment to the bottom of the pocket *B*, from where it can be removed as necessary by the cleanout *A*.

A pocket is provided in the expansion chamber to receive the diaphragm *F*, which is simply dropped in; no adjustment of any kind is required. Provision has been



SECTION THROUGH MONASH THERMOSTATIC VALVE made by the use of a spring bumper *G* to take care of the overexpansion of the diaphragm and prevents its collapse.

The thermostatic valve is manufactured by the Monash Engineering Co., 107 West Jackson Boulevard, Chicago, Ill.

* *

Erosion of Boiler-Furnace Arches

By Morgan B. Smith

SYNOPSIS—A method of studying arch erosion by measurement and the results observed in connection with the Roney and Murphy stoker arches.

*

The method herein described is based upon measurements of the thickness of the arch at definite points after its life has passed, and plotting these measurements upon sketches showing the original contours, thus giving a direct comparison.

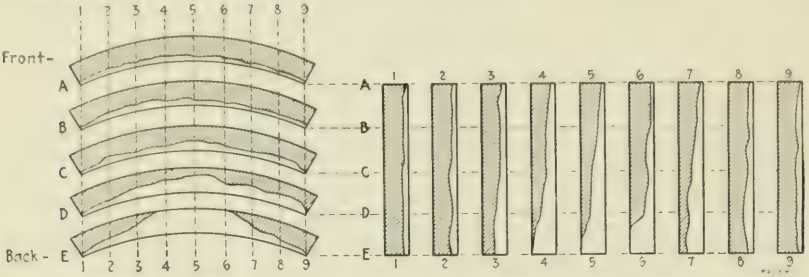


Fig. 1. Typical Erosion of Boiler-Furnace Arches over Roney Stokers with Natural Draft

The first step is to lay off the under surface of the arch, or, in fact, the upper, if such is accessible, into as many parts as are essential, varying with the size. In the present case, five transverse and nine longitudinal sections were made. Measurements are then taken at the intersections of the tranverse and longitudinal lines and charted. They may be taken as the arch is torn down preparatory to building a new one, or, if the arch is in condition to be repaired, from a base line below the arch. The objection to the latter method is that the accuracy is somewhat doubtful because of the likelihood of deformation (settling) of the arch in service, in which case the original measurements cannot be considered comparable with those taken after service.

The arches plotted in the accompanying figures were typical. It has been found that the erosion in one arch over a Roney stoker is similar to that found in other arches over the same stoker; this is also true of the arches over the Murphy stokers, whose typical erosion is quite unlike that shown in those over the Roney stokers. Arches over chain-grate stokers show much the same configuration as those over the Roney.

For brevity, only two types of erosion are shown, with the most marked differences in average contour, due without doubt to the dissimilar design of the stokers. The Roney stoker feeds from the front toward the rear along grates inclined at about 40 deg. from the horizontal, whereas the Murphy feeds from the sides along inclined grates which form a V-shaped fuel bed. In the case of the Roney stoker, the fuel bed is practically a plane surface. The same fuel, Hocking Valley slack, was used under all the arches examined.

Fig. 1, showing the erosion typical in arches over Roney stokers, indicates a remarkably uniform wearing away of the firebrick, the rate gradually accelerating toward the rear of the arch and being maximum at the center. This maximum erosion embraces two full longitudinal sections (4-5 and 5-6) and a portion of one transverse section (D-E). The cause is the concentration of heat at this portion of the arch, the heat taking a converging path from front to rear. This arch was two years and three months old when measured.

Different conditions are encountered in Fig. 2, which shows the erosion typical in Murphy stoker arches. Here there is a zone of comparative freedom from erosion along the center; in fact, embracing nearly all that part between longitudinal-section lines 4 and 6 and transverse lines *A* and *E*. This is most clearly shown in transverse section *D*, in which the action of the gases from the grates at the sides is plainly indicated between longitudinal lines 3 and 4 and 6 and 7. In the last transverse section *E*, this peculiar contour is eliminated, due to the concentration of heat and the increase in gas velocity. The life of this arch was two years and one month.

The data given show that something should be done in the design and construction of furnaces to secure more uniform erosion in service. In the case of the Roney stoker, the problem seems fairly easy, there being two courses open or, rather, three: Thickening the arch at the center toward the back, inclining the whole arch upward

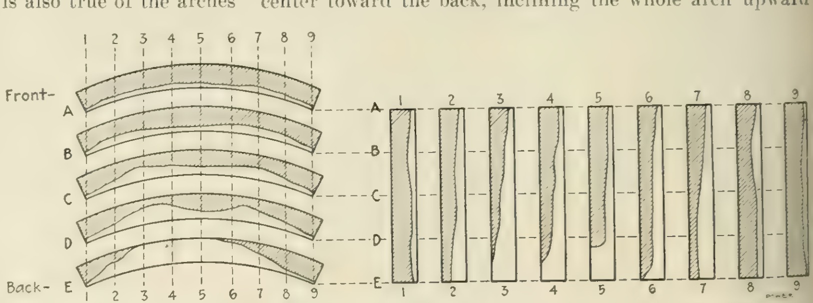


Fig. 2. Typical Erosion of Boiler-Furnace Arches over Murphy Stokers with Natural Draft

toward the rear or, at least, that portion embraced by section lines *D* and *E*, or eliminating the arch entirely. That the last course is feasible is indicated by the fact that to the writer's knowledge two Roney stokers are being successfully operated with no ignition arch whatever, the so called stoker arch being 20 in. in length. The boilers are 500 hp. Stirlings, operating on natural draft with Hocking Valley slack. With this arrangement more economical steam generation was secured than with the regular 6-ft. ignition arch formerly employed.

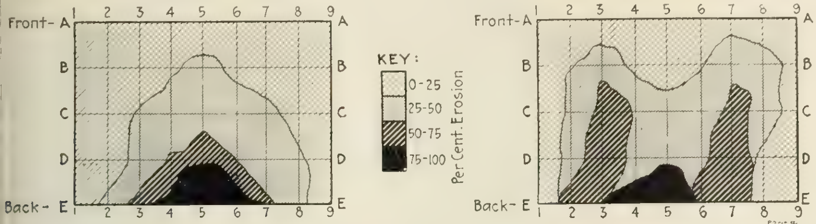


FIG. 3. RONEY STOKERS FIG. 4. MURPHY STOKERS

PLAN SKETCHES OF ARCHES SHOWN IN FIGS. 1 AND 2

Figs. 3 and 4 are plans of the arches shown in Figs. 1 and 2, giving the same information in somewhat different form. The paths of the gases along the surface of the arches are shown, and the thought is brought out that there are areas which probably never reach the maximum temperature of the hottest portions. It is evident, therefore, that the arch is under terriffic strain all the time, this effect probably being a torsional stress to some extent and accounting for the grinding away of the nds of the arch brick in certain portions.

It is certain that arch design could be advantageously hanged so that the paths of the gases would be more niform over the arch surface and that the heating would, onsequently, be more uniform.

Effort in this direction is now being made with some rches of new design under the writer's supervision, but t is too early in their life to state the results obtained. It nay, however, be stated that, so far, the results appear o have justified the redesigning of the original arches.

It is likely that the lines of contour in arches over hese same stokers but using a different coal, say, a heavy oking coal, would be different from those found in the resent investigation. It is probable that in such a case he heating of the arches would be somewhat more uniorm and the lines of contour less sharply marked.

⁂

Tests of a Small Diesel Engine

In a paper before the Institute of Naval Architects, rofessor Dalby presented the results of some tests on a nall Diesel engine at the laboratory of the City and uilds College. The engine was a 6½x10⅝-in. singleylinder, operating on the four-stroke cycle and nominal- rated at 10 hp. Governing was effected by controlling ie action of the suction valve on the fuel pump, and in eneral there was little to distinguish the engine from her types of Diesels.

The figures of the test herein shown are instructive, it the chief interest lies in the indicator diagrams which ere taken photographically by an optical indicator. In is indicator no spring or piston is used and the pressures within the cylinder are measured by the slight deflection of a diaphragm connected with a small mirror, which is thus caused to tilt. A second mirror, whose axis is at right angles to the first, receives an angular motion proportional to the piston displacement. A beam of light from within the apparatus falls upon each mirror in succession and is brought to a focus on the ground-glass screen of a camera. When desired, the screen is replaced by a photographic plate.

Interposed between the second mirror and the piston mechanism is an arrangement called a "phase changer," driven from the crankshaft by means of sprocket wheels and a chain. The ratio between this small crank and the connecting-rod is the same as that between the actual crank and the connecting-rod of the engine. This enables the events on the diagram to be changed through any number of degrees. When the phase is changed 90 deg. the "dead point" period is exhibited on a time base instead of a piston-displacement base, so that the variation of pressure in this region can be more closely studied.

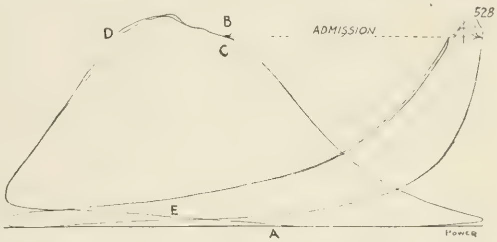


FIG. 1. NORMAL DIAGRAM AND ONE DISPLACED 90 DEGREES

Fig. 1 is such a diagram, the right hand showing the normal diagram and the left hand the same diagram with the events displaced 90 deg. The compression in the altered diagram begins at *A* and extends to the right and up to *B*. At *C* the fuel valve was opened, and the expansion curve begins at *D*, continuing until the exhaust valve opens somewhere near *E*.

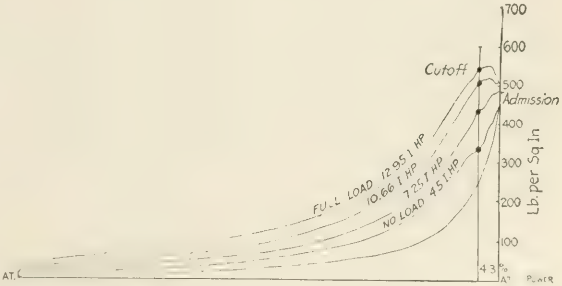


FIG. 2. SUPERIMPOSED DIAGRAMS TAKEN WITH OPTICAL INDICATOR

In Fig. 2 the four diagrams taken at different loads are shown superimposed. The cutoff was the same in each case, being fixed by the cam. It will be noted that the compression curve is practically coincident for each diagram, and that burning of the fuel takes place at a slightly rising pressure during the full-load diagram. As the load is decreased, the pressure gradually decreases.

RESULTS OF TESTS ON 10-HP. DIESEL ENGINE

	No Load	¼ Load	½ Load	¾ Load	Full Load
Duration of test, min.	60	60	60	60	60
I.hp.	1.5	5.27	10.66	11.69	12.95
B.hp.....		3.33	6.71	8.35	9.94
Mechanical efficiency, per cent		63.8	63	71.4	76.75
Oil per i.hp.-hr., lb.	0.33	0.33	0.34	0.37	0.42
Oil per b.hp.-hr., lb.		0.71	0.54	0.52	0.55
R.p.m.	270	264	259	256	250
Mean effective pressure, lb. per sq.in.	37.6	61.6	92.1	102.9	117.7
Pressure in storage bottle, lb. per sq.in.	875 to 1060	1080 to 1070	1075 to 1095	1100 to 1110	1112
Maximum pressure in cylinder, lb. per sq.in.	469	478	535	529	531
Blast pressure	483	575	675	700	715
Drop of pressure through fuel valve	14	97	140	171	184
Cooling water, lb. per i.hp.	133	93.5	64.5	57	54
Rise in temperature of cooling water, deg. F.	12.6	15.3	20.5	23	29.2
Heat equivalent to i.hp. percent of heat supplied	45	46	44	41	36
Heat carried away by cooling water per cent. of heat supplied	31	26	23	21	22
Heat carried away by exhaust radiation, etc., per cent	24	28	33	38	42
Thermal efficiency based on i.hp., per cent	45.3	46.4	44.4	40.6	36
Thermal efficiency based on b.hp., per cent		21.1	28	29	27.7

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Alternate Coal and Gas Firing

It is not often that in stationary steam-boiler installation the need arises for a combination of automatic coal firing with apparatus for burning gas in the boiler furnaces; therefore a brief description of a boiler installation recently erected at the works of the South Staffordshire Mond Gas Co., Dudley Port, Tipton, England, will be of interest.

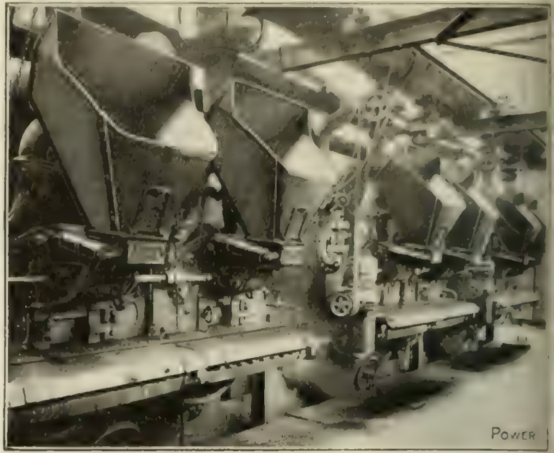
This plant consists of three Lancashire boilers, each 9 ft. in diameter by 30 ft. in length, with extended flues, the boilers working at 120 lb. pressure, fitted with superheaters and with an economizer of 4000 sq.ft. of heating surface. The grate area of each boiler is about 57 sq.ft.

The plant also includes eight producers capable of gasifying 20 tons of fuel per day of 24 hr. and supply gas engines of 2000 hp. capacity. The gas from the producers is washed and cooled, and after the ammonia has been extracted, it is sent through the scrubbers and meters to the compressors and transmitted at high pressure through a system of gas-distributing mains.

The boilers illustrated were at first hand fired, but in 1910 it was decided to substitute mechanical stokers under a guarantee that each boiler would give an evaporation of 12,000 lb. of water per hour, an overload evaporation for short periods of 15,000 lb., and an overall efficiency of 72 per cent. On test the guarantee figures were exceeded, an overload evaporation of 17,000 lb. of water being obtained.

In the operation of the plant it was necessary to keep steam up during the night, and also from the noon hour on Saturday until the start of regular work early Monday morning, and obviously it was advisable to reduce the labor costs as much as possible during this interval. Therefore, gas firing was adopted for night and week-end periods as an auxiliary to the mechanical coal-firing system.

On the top flange of the stoker front, gas ducts are led into the boiler furnace and secured by a gas-tight joint. Baffle-plates are so arranged that a passage is provided having an outlet immediately over the grate for the gas from the ducts to the furnaces there being four ducts to each boiler, two in each flue; each pair is connected by a pipe behind the coal hopper to the gas supply. Air is conveyed to the furnace by means of separate air ducts and does not mix with the gas until it is required to promote ignition inside the flue. A valve with an adjustable cover is placed on the furnace front for regulating the supply of air.



Boiler Furnaces Fitted for Burning Coal and Gas Fuels

So satisfactory has this duplicate method of firing proved in practice in the two years this installation has been used, that recently, when an extension of the boiler plant was required, the same system was adopted. Careful check was kept on the performance of the plant and during the running test, which extended over six months, under all usual conditions and variations of load, including times when portions of the plant were laid off for cleaning and inspection, it was found that the thermal efficiency was as high as 73 per cent. The average amount of water evaporated per hour per boiler over a month's running was 14,880 lb., when the water was previously heated in the economizer. During this period the boilers were fired in the daytime with slack coal by the automatic stokers and by gas during the night and week ends.

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A Demonstration of the possibility of steam raising by the combustion of liquid fuel directly in contact with water has been made in Bremen, Germany. An apparatus consisting of a cylindrical boiler, provided with a number of pockets isolated and drained by suitable valves and drain-cocks, was used. Each of these pockets contains an oil burner, with a pilot burner, by means of which the main burner can at starting be sufficiently heated to effect complete combustion of the oil. When the main burners are well alight, water from the boiler is permitted to flow into the previously drained pockets, and the circulation of heated water commences, the products of combustion as well as the steam generated being used as a source of power in a steam engine.—"Popular Mechanics."

⁂

A 951-Ft. Transmission Span—The British Columbia Electric Ry. Co., of Vancouver B. C., has just installed a new 34,600-volt transmission span over the Second Narrows of Burrard Inlet, to supply energy to North Vancouver and adjacent districts. The span measures 951 ft. between towers and at its lowest point clears the water by a height of 160 ft. in order to permit large vessels to reach industrial plants at the head of the inlet.

Editorials

Ambition

A good thing to have, when the right kind, is ambition. What does it mean? Well, without consulting our Webster, we should say, "Ambition is a desire to succeed." With that as the definition, it is very apparent that the first statement cannot be challenged. Certainly, it is commendable to have a desire to succeed in the right kind of an endeavor. Further, to bring the application home, it is laudable for an engineer to aim to be the best engineer he can possibly be. If he keeps this before him as the goal he wants to reach and does not cease trying for it, he is pretty apt to become a credit to himself and his profession.

So much for the object. Now what is necessary that it may be attained? The answer is "Do not lose your ambition." To the young man, such advice is seldom needed. Youth is a period of hope, and ambition a natural characteristic at that time. The man who has no ambition while he is young is a failure before he starts. Time spent in counseling him is wasted. We are sorry for him, but we cannot help him, so we will dismiss this chap with our pity and turn our attention to another class.

Many, many men, sad to relate, now not so young as they once were, started with high hopes and plenty of ambition, but they have been dropping by the wayside. They got in a rut, became tired and discouraged, and their ambition just naturally died before they got out of the realm of the mediocre. Now they are just plodders. They too are to be pitied, but there is hope for all of them if they can be aroused to the truth that ambition, like muscle, must be exercised, or it becomes weak. Like physical strength, it decreases with age and much more rapidly if it is neglected.

If we were to be called in as a physician to prescribe for this mental ailment—loss of ambition—we should first say take courage as a tonic, your successful friends, who had no more latent ability or educational advantages than yourself, as examples, and practice these exercises:

Begin with a little self-study. Why have you lost your ambition? Certainly not because there is no more that you can accomplish. You are not satisfied. At least, it is to be hoped that you are not, for someone once said that when a man is perfectly satisfied with himself, it is time for him to die. No, you want to get farther along in your work. You want a better position, a better reputation, a larger measure of the world's approval. When you have reached this determination, there is already an improvement in your condition—your ambition is returning. With something to work for, you are ready to go ahead again.

Now is the time to pause to consider what were the influences or circumstances that first dealt your ambition such a body-blow and put a "crimp" in your nerve. Perhaps you were feazed by a sense of your lack of knowledge. The remedy for that is study, and opportunities lie all around you. Pitch in—learn a little at a time. "Every little bit added to what you've got, makes just a little bit more." As you gain knowledge, apply it; then it becomes something real and worth while. The photographic plate may have been perfectly exposed, but it does not amount to anything until it is developed.

Hunt around your plant for the things that are not up to modern standards and do what you can to improve them. Even if you cannot make them better unless the management will spend the money you recognize as necessary, and it refuses to do that, you still have the gain of knowing why they are not right and what right is. You can use this knowledge in the next step upward. Or, if your suggestions are heeded and you are allowed to make the improvements, you will rise a lot in the estimation of your employer.

When your ability has outgrown your present situation, cast about for a better one. Don't wait for it to seek you. Never settle down on any one place as a life job, while there are better ones for which you are fitted or can fit yourself.

Perhaps you will interpose the plaint that you have a family to support and you can not be too independent, etc. That is the very thing that ought to stimulate one's ambition, but all too often is what kills it. If you have a real helpmate at home, she will take a chance for your sake. If she is not that kind, alas, it is a serious handicap, but it is the greater credit to you if you can win in spite of a drag. Many a fellow who got there owes it more to his wife than himself.

Finally, do not be easily discouraged. Be patient over your failures and setbacks, but do not be resigned. Keep some mark in sight, and as each one is reached set a new one. That is ambition and it spells success.

⁂

Coal Testing

In line with the preceding editorial, one thing any engineer can do to make himself a better engineer is to test his coal. On page 657 is described a simple, homemade retort for heating and burning coal samples to make a proximate analysis.

The habit of testing the coal as delivered is a mighty good one. Let the coal dealer know you have this habit and he will be more particular to send you good coal. Let your employer know you have it and tell him he can save money, if he can, by getting better coal and he probably will have more respect for you and manifest it in agreeable and substantial ways.

You will need scales to weigh your samples before and after driving off the volatile matter and burning out the combustible. It is not necessary to have an expensive laboratory balance. Scales come in cheap enough forms (good ones can be had for two dollars) for you to afford them out of your own pocket if necessary, though it probably will not be left for you to pay for them when you have explained what you want them for.

Take the ash determination, for instance, just divide the final weight, deducting the weight of the crucible, by the first weight, less the crucible weight, point off two places in the answer and you have the percentage of ash. If it is over, say eleven per cent. for anthracite, sixteen per cent. for bituminous, and twenty-two per cent. for slack, you may know that you can get better coal, and probably should. However, the cost of the coal is always to be taken into account. Sometimes a poor coal is enough cheaper than coal a little better to be more economical in the long run. This presupposes that the furnace conditions are right for burning the poorer coal. In any event, do not neglect consideration of the added labor and more rapid destruction of the lining, if they prove to be the consequences of burning the poor coal.

With each new grade of coal tried, it is well to make a complete proximate analysis. After that an ash determination will show about what to expect and whether subsequent deliveries are up to the first one that got your dealer his order.

By the way, bear in mine the idea that is being taken up so rapidly—of buying coal on specification. We have printed considerable on the subject lately. There are tremendous possibilities in the practice. It is not unlikely that you may find it of advantage in your plant.

⁂

Boiler-Furnace Series

Closely akin to the subject of coal, just referred to, is the matter of how it is burned. In this issue is printed the first of a series of articles relating to the construction of boiler furnaces by Osborn Monnett, smoke inspector of the city of Chicago. This one is entitled "Gas Passage in Return-Tubular Boilers" and, as explained in the synopsis at the head of the article, applies to the use of Middle West bituminous coals. Many of our readers are dealing with just these kinds of coal and will find helpful information in this discussion.

Other installments to follow will treat of the arrangement of baffles and dampers and the design of uptakes and flues, etc. Two or three will deal particularly with draft. Number seven in the series will be entitled "Analyzing an Existing Plant" and should be specially interesting to those who feel that their equipment could give better results, but do not know just where the faults lie. Another later installment will be of value to everybody, as the title alone shows, "Rules for Firing without Smoke." We are not disposed to show any more of our hand now, but we will say this: "We have a fist full of trumps."

Presenting this series at this time is in keeping with our plea for more attention to the boiler room. It has not been getting its share as compared with the parts of the plant where the steam is used. "Saving at the spigot and wasting at the bung" is what every plant is doing that strives for the most economical steam consumption without regard to the wastefulness of the steam production. In the total efficiency from coal to power, by far the greatest loss is in the boilers and furnaces. A little saying here can offset a big lack of economy in the engines or turbines.

We sincerely trust that these articles will be read with profit by a large part of our readers. They will be well worth thoughtful perusal, and we hope that they will not only be read and digested, but that they may be the means of greatly improved conditions in very many plants. We take not a little satisfaction in having secured these articles from so eminent an authority as Mr. Monnett. He has done and is doing splendid work in Chicago, and when he went to that field from the editorial staff of POWER, what we lost was Chicago's gain.

⁂

Introducing Will Quizz, Jr.

Gentlemen, shake hands with Will Quizz, Jr., who makes his first appearance "in our midst" on page 666. He is a fellow you all know well. A human interrogation point, and found in nearly every power plant. To some, he seems a pest, but he really is a benefit because his observing and critical disposition keeps the chief on the alert. And so it is with his boss, Chief Teller, the other principal character in this series of articles that will appear in POWER as often and for as long a period as they seem to be welcome. Incidentally, Teller is the kind of a chief we were pleading for in the editorial, "Helping the Helper" in last week's issue.

The purpose of the series will be to take up questions that bother the younger fellows particularly, who are just being broken into the power-plant harness. Obviously, therefore, these articles need not be expected to be very profound, but we do hope that they may prove a pleasant, easily assimilated way to administer a little information on some commonly misunderstood questions—sort of sugar-coated, as it were. Treated in the conversational or correspondence manner, it is the object to add the element of human interest and so make an ordinarily dry description a little easier reading.

In this way some questions that cannot be adequately covered in the briefer answers, we are compelled to give on the "Inquiries of General Interest" page may be taken up by "Will" with "the Chief" in more detail. We can not promise to use every question sent in for this treatment, but as the purpose of this series is to help the perplexed readers, we invite suggestions as to subjects, or contributed installments.

⁂

Speak Up!

The year's test at the New York City Hall of Records ended last December. Five months have now elapsed and the engineering fraternity is still anxiously awaiting the verdict.

As far as the test itself is concerned, the report has been completed and submitted. The matter is now in the hands of the advisory committee, which will determine the fixed charges. One is led to inquire, and with apparent justification, why the committee has taken so long to arrive at the fixed charges. What were they doing while the test was in progress? Surely, a year was ample in which to decide these charges, so that they could be submitted simultaneously with the final results of the tests and thus expedite the complete report.

As we have pointed out before, the affiliations of different members of the committee would indicate a division of opinion as to the fixed charges and we should not be surprised to see this result in a majority and a minority report. Whatever the outcome, let there be no more needless delay, for, in the eyes of the public, unexplained delay creates suspicion, even though it be unfounded.

Correspondence

What Did the Engineer Get?*

The cry that W. H. Odell puts up, in the issue of Apr. 14, is the same one many another man has adopted for his standard, i.e., "Look after the condition of your own pocketbook!"

Let me say, there are several ways of looking after your pocketbook, but only one legitimate way, and that is to give your employer the best service that is in your power.

If Engineer Wise could save $7030.40 per year for the company, it was his duty to do so. When an engineer enters the service of a company he should work for its interests in all things. If Engineer Wise had allowed the conditions in the plant to remain as they were under the former engineer, do you think he would have been giving value received for his salary? It is all very well for us as engineers to criticize our brother workmen and our employers, but there are two sides to every question, and one of them is our employer's. If I deliberately let $7030.40 (or any part of that amount) of my employer's money go to waste, I am not entitled to the name of engineer. Such men are a big asset to the central-station company, as they make it impossible for the isolated plant to exist.

Getting down to the "How about it?" in the article: If Engineer Wise had gray matter enough to see where the leak was, and had the moral courage to stop it, he demonstrated that he knows his business. As soon as you can do that for any employer your salary is not a question of dollars and cents; you are an asset in his business, and the salary will adjust itself according to your ability. That is all the "How about it?" there is to it.

O. Newton.

Cleveland, Ohio.

The question brought up by W. H. Odell, in the issue of Apr. 4, on page 528, has been asked in other cases. The answers usually intimated that the engineer who is only n the business for the money he can get out of it will never make a high-class engineer; that his heart and mind should be so absorbed studying theoretical and practical problems that expecting to get or even thinking about money should be a minor consideration.

Advice is handed out to persevere onward and upward n the path of knowledge, and ultimately your worth will be noted, Success will grab you, and you will then have the earth at your feet, placed there by the god Success, or you to kick where you list. You know better! Study nd experience are good, the best in the world; get all ou can, as you cannot get too much of either. But hen by your knowledge you succeed in saving your employer's money, do not neglect to let him know it. Tell him that you have used up your time, money and energy n making yourself a valuable man, and that you expect ay for it.

An engineer is unjust to himself, to his family and to other engineers if he does not see that he gets what his services are worth. Do not attempt to put coin in your pocket at the unauthorized expense of your employer. Graft in any shape on goods used in your own plant is simply sneak-thief stealing. If you pay yourself by robbing your employer, you are only lowering yourself, and the boss who will underpay his employees is much the same. It is a good plan when starting on a new job to ask your employer if he will allow you a percentage of the saving you can make, always providing that you give as good or better service than he has been receiving.

However, it is your duty to do your best for your employer whether he pays you extra for it or not. He is only compelled to pay you what he promised, but when you do take a job at any salary, big or small, give your employer the best you have to give.

James Thorn.

Toronto, Ont., Canada.

W. H. Odell wants to know what I got for looking after my employer's coal pile as well as my own interest. I got a check for $100. The saving on coal is only about half of the total savings per year. There is the saving on packings, oil, etc., and all outside shop bills; all overtime and Sunday work were cut out. The increased production is due to the many changes I have made. It is impossible for me to get the exact figures of the output from the firm, so I asked the foreman of the mill room how the output now compares with what it was when I took hold four years ago. He said it had increased about five times, judging from the orders got out then, and now.

I know that we are doing more work, because we have quite a time getting orders filled, working until nine o'clock three nights a week.

Readers may want to know why I do not quit. Well, I probably would if I could get a position which would pay me more than I am getting now. We hear a lot about competent men being at a premium. I must be very incompetent. I quote a few of my experiences in looking for a better-paying position. I tried for one as chief engineer in a printing plant. The manager told me that the engineer they had was not competent, that they paid him $35 a week; that there were ten men in the department, and that the plant was in bad shape. Would I take the position for $25 a week, discharge four men and get the plant in shape? Then they would consider what I was worth. I declined the offer. Next I put in an application for a 3000-hp. manufacturing plant, and was asked if I had ever had charge of stationary plants as large as that. I had not, so I was judged not competent to fill that position. My next endeavor was in the office-building line. Had I ever been in charge of an office building? No, again. I was not thought competent.

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*"Power," Mar. 10, p. 346; Apr. 21, p. 561.

So here I am, open for any position that will pay me the money I want. Until I can do better, however, I will stay where I am until the bank account and the family have grown large enough for me to quit for good.

C. H. WISE.

New York, N. Y.

⁂

Operating a Powdered-Coal-Burning Boiler

After reading the article by William A. Evans on "Powdered Coal in Boiler Furnaces," readers will probably like to hear something about the Bettington boiler in actual service.

It is unfortunate that, having brought the Bettington boiler to its present state of efficiency, Mr. Bettington should have lost his life while making an aëroplane flight in England, about 18 months ago, and left still unsolved so many problems connected with the use of powdered fuel.

For about two years the writer had two Bettington boilers under his charge, and so had ample opportunity to study this type under working conditions.

Some auxiliary source of power is necessary for working the pulverizer while steam is being raised. This, of course, presents no difficulties in a large plant, but it might embarrass the use of the boiler in a small plant.

Igniting the fuel is a simple matter. A specially devised lighting torch using kerosene is placed just over the outlet of the fuel pipe, and the pulverizer started. In a few minutes the fuel ignites and the torch is withdrawn. The circulation is rapid in the Bettington boiler and steam is quickly raised. The writer has known the boiler to be "cut in" with a pressure of 150 lb. gage 30 min. after the torch was applied, the temperature of the water in the boiler being about 65 deg. F. when starting. Owing to the rapid evaporation and the limited water space, the water gage-glass must be closely watched. If the feed water is cut off the water disappears from the glass in a few minutes.

Damp coal must be avoided or the screens in the dust-separating chamber or carburetor will choke up and prevent any feed passing to the furnace.

The pulverizer also acts as a fan, the air and fuel being intimately mixed in the dust chamber. The fuel and the air supply can be regulated independently. Peepholes allow the state of the flame to be seen at any time. One point that must be carefully watched is the dished plate which forms the bottom of the top header. By referring to Fig. 6, page 472, of the Apr. 7 issue, the reader will see that this plate forms the top of the combustion chamber and is subjected to a fierce heat. It must be kept clean; in one case this plate was burned through, probably owing to dirt collecting there.

Although this boiler will use low-grade fuel successfully, this advantage is greatly offset by high cleaning and maintenance charges. Firebrick of a special shape is used to surround the inner row of tubes and form the combustion chamber. In spite of the cooling effects of the tube, these bricks are quickly burned away and frequent renewals are necessary. The brickwork should be closely inspected at every opportunity or holes will be burned through and the gases short-circuited to the chimney. The heaters and liners of the pulverizer are subjected to rapid wear and tear, and call for frequent repair and renewal. While under steam the boiler is easil managed, and one fireman can look after several boiler without any trouble.

The Bettington boiler has certainly gone a long wa in solving the problem of using powdered fuel, and w may expect to see big developments in this direction during the next few years.

HENRY E. BRENNAN.

Quartz, Ont., Canada.

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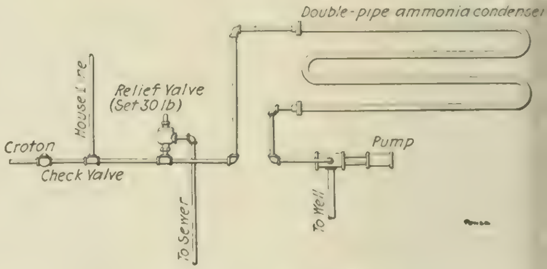
Ammonia Condenser Water for House Purposes

Our ice bills for the last few seasons were so high tha it became necessary to install a 15-ton plant. After th plant was completed, the question arose of getting wate for the condenser. Croton being too expensive, I suggested that we bore a well; this was done without delay.



AMMONIA CONDENSER AND HOUSE-WATER CONNECTIONS FOR WELL WATER

The condensers required about 30 gal. per min., which we had to let go into the sewer. Formerly we used Croton water mostly for flushing purposes, and our water bills were about $1000 a year.

I was asked by the management to devise some plan by which we could use our well water for flushing. I first thought of installing a tank on the roof, but while getting the estimates I tried out another idea, as shown. This plan is working perfectly, with but little expense to install and at any pressure desired.

GEORGE ZIMMER.

New York City.

⁂

Pier in Furnace Lowers Evaporation

The smoke department of a city in the Middle West got after a plant that was violating the smoke ordinance. So persistent was the department that the owners got tired of reading letters, and on the advice of their chief engineer wrote the inspector that they had installed the kind of a stoker he had recommended when they built the plant; and inasmuch as they had complied with his recommendations it was now up to that office, but if he had any suggestions to make, they would be pleased to consider them. Up to that time the evaporation had been good, being from 8 to 9 lb. from and at 212 deg. F.

Here is what the smoke department suggested: That they build two piers on the bridge-wall and one midway between the bridge-wall and the back end of the grates, each pier to be 24x24 in., and to extend up to the bottom row of flues. The company acted on the suggestion, and after the piers were built it got the approval of the smoke department.

Then the boiler was put into service, and the evaporation dropped about 3 lb., or from 8 to 9 lb. down to 5 to 6 lb. The object of the piers was to give the gases a rolling motion and retard them by holding them in the furnace until burned. The temperature in the dutch oven ran above 3500 deg. F., while in the breeching it was only 480 deg. F., with a draft over the fire of 0.27 in. and of 0.48 in. in the back combustion chamber. As much as 13 per cent. CO_2 was obtained with the automatic damper closed. The steam pressure carried was 125 lb. After all these readings were taken several times to make sure that they were correct, it became evident that there was something radically wrong. A systematic investigation was made, and then the chief came to the conclusion that the piers were the cause. Unknown to the smoke inspector, the engineer removed the center pier, leaving the two on the bridge-wall, thereby allowing the hot gases a freer passage.

The result is the evaporation now runs 7 and 8 lb., the raft over the fire, 0.32 in., the draft in the back comustion chamber, 0.54 in., the temperature in the dutch ven is 2800 to 3000 deg. F., the temperature in the reeching 540 deg. F., with a CO_2 reading of 12.4, and he smoke is eliminated.

O. Newton.

Lakewood, Ohio.

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Boiler Setting for Burning Wood

Our plant serves a wood-working establishment. We ad a 72-in. by 18-ft. horizontal tubular boiler to be set or burning wood, and while it is always customary to et boilers further from the grates for wood than for coal, n this case we set the boiler as shown.

Fig. 1 represents a front and Fig. 2 a side elevation of he setting. It will be seen that the grates were set 3 ft. in. at the back end from the boiler shell, with a 4-in. op toward the fire-door, making them 4 ft. at the front id from the boiler. The bridge-wall is 18 in. from the ell, and the back of the combustion chamber 12 in. om the boiler. The aim with this style of setting was create a "scrubbing" contact on the shell. Wing walls ere built at the back end of the boiler to baffle or retard e flow of the gases.

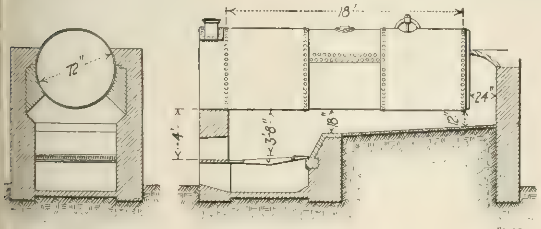

FIG. 1 FIG. 2

Setting for Burning Wood Fuel

There was much criticism of this furnace by the local gineers, but a few weeks after it was started we found at the wood could be sold to advantage. Then we ben burning coal. Many predicted that we would surely ve to change the furnace, but we continued using coal with better results than are obtained with boilers having lower settings.

We did not determine the percentage of CO_2 in the gases, but I feel confident that it was high. The test showed an evaporation of 8¾ lb. of water per pound of coal.

H. R. Rockwell.

St. Louis, Mo.

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Electric-Crane Troubles

A piece of apparatus which often does not receive the proper attention is the electric crane. Some persons are under the impression that almost anyone can operate and take care of an electric crane, which, however, is not true. It pays in the long run to have an experienced man in charge. An inexperienced or careless operator may ruin the motors, the bearings and the other apparatus on a crane in a short time. In large manufacturing plants, where there are a number of cranes in use, it is good practice to place all the crane operators under the charge of one man, who may be the chief engineer.

In many plants the crane runway is not kept in line, the flanges on the bridge wheels are worn off and much power is unnecessarily wasted, besides the wear and tear on the crane.

Where crane motors have run for a number of years, the bearings should be examined to see if they are worn. Allowing the armature to rub against the field coils, if not noticed and repaired in time, may ruin the armature as well as the field coils. Worn bearings on a motor will cause other troubles as the armature and commutator will not run true and the brushes will not make good contact at all times, resulting in sparking.

The motor which drives the bridge on one of our cranes started to spark one day and at times it would not carry the load. At first it was thought that there was a short-circuit in either the armature, the commutator or the field coils. When these were examined and tested they were found to be all right, and it was later discovered that the bearings were worn, also the commutator was worn out of true. Upon renewing the bearings and turning down the commutator, the trouble ceased.

Some operators have a habit of sandpapering the commutator by holding a piece of sandpaper on with nothing but the hand. As a result the commutator is apt to have an uneven surface and there will be more or less sparking at the brushes. When it is necessary to sandpaper the commutator the sandpaper should be held in place by a piece of wood rounded to fit the commutator. If the commutator is very rough a fine sandstone will give better results.

Still another bad practice, when sandpapering the brushes, is to remove the brushes from the holders; the proper way is to leave them in the holders and place the sandpaper under the brushes, then pull forward and backward.

Some operators are careless in sandpapering the contact points on the controllers. They do this work by holding the sandpaper in the hand and rubbing forward and back over the contact points. In a short time the contact points will have an uneven surface, and it will be impossible to prevent the fingers from sparking when passing from one contact point to another. I have seen controller contact points sandpapered in such a careless way that the heads on the brass screws, which hold the contact points in place on the controller plate, were nearly worn away from the sandpaper. It is better to lay the sandpaper on a piece of wood which has a flat, even surface, then there is not the danger of wearing some parts of the contact points more than others.

With cranes in places where there is much dust and foreign matter, the armature-field coils and the controller should be cleaned out frequently with air under pressure. While most crane motors are of the closed type more or less dirt usually finds its way into them.

On some electric-crane motors the tension on the brushes is maintained by small coiled springs placed on the brush-holder, but which are not adjustable. At times these springs become weak and slight jars will lift them partly from the commutator, and sparking results.

The bridge motor on a crane would not start. It was discovered that there was no current at the motor with the controller lever in starting position. After examining every part and following up the wires from the motor to the collector shoes, it was found that one of the wires leading from the collector shoe to the motor was broken off at the shoe terminals, but in such a way that it could not be easily detected.

In another case, the trolley-drive motor on a crane located outdoors would not start. Nothing was wrong with the motor and conections, but there was no current at the motor with the controller lever in running position. Then the collector shoes at the trolley wire were examined more closely, and it was discovered that there was ice between the bottom of the collector shoe and the trolley.

H. A. JAHNKE.

Milwaukee, Wis.

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Adapting Fan to Boiler Loads

The writer recently had a peculiar experience with the installation of a forced-draft system for four horizontal tubular boilers which illustrated the importance of the proper relation between fan capacities and load requirements for installations of this kind.

An effort was made to use an old fan the customer had on hand, but of which no exact capacity data could be secured. Provision was made, however, that if the fan proved unsuitable, one of standard design and of known capacity could be substituted.

The customer's fan was of the high-speed, multiple-blade type, directly connected to the steam turbine. When the system was installed and the boilers were fired, we found that we were unable to carry the ordinary load, evidently not developing the capacity of the boilers, although we had a very hot fire on the grate. After much experimenting by changing the fan speed, reducing the speed of this type decreased the pressure more rapidly than it reduced the capacity, and by the time we had the proper quantity of air it was furnished at such low pressure that the fires would deaden.

We then foolishly tried speeding the fan to get a pressure of about 1 in. of water, and attempted to restrict the quantity by throttling the intake of the fan; this was our only recourse without suspending operations to do some work. Naturally this produced no result except that it increased the speed of the air in the suction intake.

After working through the day with considerable difficulty to carry the load with a CO_2 percentage running from four to eight, we had the brick duct from the fan to the boiler opened during the night and a sliding opening made, so that we could run the fan at the reasonable pressure and waste a part of the air.

The next morning we took a CO_2 analysis with the slide closed and secured 4 per cent. Immediately afterward, by opening the slide, the percentage of CO_2 jumped to 11.

In a short time we were able to cut out one boiler and carry the load with three. We operated the fan in this way for about a week, or until we could secure a fan of the proper size. This plant is now running with a saving of about one-third less fuel than was used with the practice prior to the making of this forced-draft. hand-fired installation and the removal of the stokers.

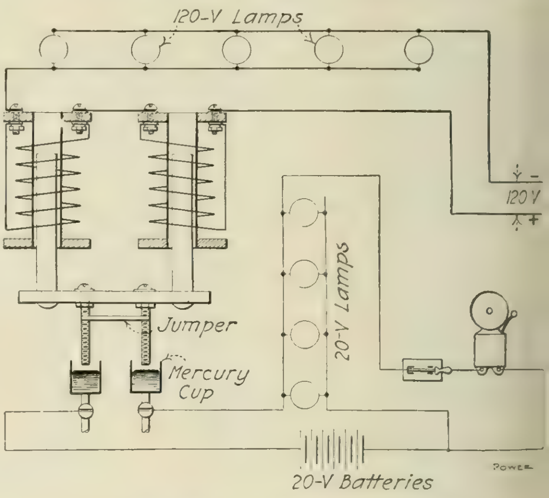
J. H. DIETZ.

Cleveland, Ohio.

Emergency Lighting Switch

On several occasions I have had the circuit-breaker go out and leave the plant in darkness, so I concluded to rig up an emergency lighting circuit which would automatically come into use when the circuit-breaker tripped or the voltage dropped an appreciable amount. For this purpose a 20-volt, 15-ampere storage battery, ordinarily used for our bell circuits, was employed and a switch devised as shown in the sketch.

The switch consists of two solenoids in series and in circuit with five lamps across the 120-volt line. These lamps take 2½ amperes collectively, which current is necessary to operate the solenoid. Attached to the yoke of the solenoid are two brass screws, connected by a jumper and thoroughly insulated from the yoke.



CONNECTIONS OF EMERGENCY SWITCH

When the circuit-breaker goes out or the voltage drops below a certain value, the solenoid drops and the two screws complete the battery circuit through mercury contacts. Thus a number of five-watt, 20-volt lamps are lighted at convenient places in the engine room. There is a bell in parallel with the lamps and when the switch is closed and the solenoid operates, the bell will ring also.

WILLIAM PATTERSON.

New York City.

Inquiries of General Interest

Gasoline Engine Release Pressure—What is the pressure at release in a gasoline engine?

W. T. O.

It depends largely upon the timing of the exhaust valve and the explosion pressure, which, in turn, depends upon the mixture and upon the compression pressure and upon the load. With full load the pressure at release may be as high as 40 to 50 lb. per sq.in. At lighter loads it will be much less, the amount depending upon the factors mentioned.

Air Chamber on Suction Line—What is the purpose of placing an air chamber on the suction side of a pump?

J. R.

Where a pump suction is supplied under pressure and especially when a single-cylinder pump is used, an air chamber in the suction line near the pump is useful in affording a cushion for absorbing the shock of water hammer which results from suddenly arresting the velocity of water in the suction line at the end of each stroke of the pump.

Flow of Steam through Nozzle—How much steam at 120-lb. boiler pressure would be discharged per hour into the atmosphere through a nozzle having an aperture ½ in. in diameter?

C. J.

Napier's approximate rule for discharge of steam is: Flow in pounds per second = absolute pressure × area of aperture in square inches ÷ 70. As the pressure would be 120 + 14.7 lb. per sq.in absolute, and the area of ½ in. diameter is 0.19635 sq.in., then the discharge would be

$$\frac{134.7 \times 0.19635}{70} \times 60 = 22.67 \text{ lb. per min.}$$

Automatic vs. Mechanically Operated Valves—What are the relative advantages of automatic and mechanically operated valves in a gas or gasoline engine?

R. G.

Automatic valves cannot be timed, are more likely to stick, and in fast running engines must be made light and, consequently, weak. They are cheaper than mechanically operated valves, and where lightness of weight is desirable, as in aëroplane engines, automatic valves may be employed to advantage as they require neither push rods nor camshaft gearing.

Concrete Blowoff Sump—Can a suitable blowoff tank be constructed of concrete?

L. A. B.

Concrete would be suitable for constructing the bottom and side walls of an open sump or basin for holding and cooling blowoff water before discharging it to a sewer or other point of drainage. Such a sump should be fenced and placed outside of buildings and at a safe distance from foundations that would be injured by seepage from the sump which would be likely to result from cracks in the concrete due to unequal expansion when heated by the blowoff water.

Using Exhaust for Heating More Than Feed Water—Can more than one closed exhaust steam heater be connected with the exhaust of a noncondensing engine, and obtain heated water in excess of boiler-feed water required for generation of steam used by the engine and ordinary power-plant auxiliaries?

T. D. T.

Yes; by using a feed-water heater containing a proportionate amount of heating surface or connecting several feed-water heaters of sufficient size, it is practicable in most plants to utilize the exhaust in heating to the same temperature, four or five times the quantity of water required for boiler feeding.

Expression for Inductance—How is the term $2\pi f$ in the expression for inductance, $2\pi f L$, related to the flux cut per second?

F. G. K.

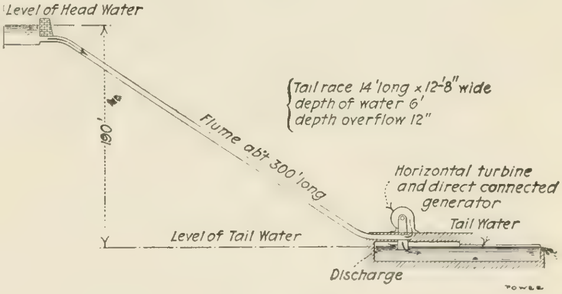
The electromotive force of self-induction depends upon the rate at which the magnetic lines of force change, and hence upon the rate at which the current changes. The maximum rate of change per cycle is 2π times the maximum current, and if the current passes through f cycles per second the rate of change of current in amperes per second will be $2\pi f$ times the maximum value of the current. If only one ampere is considered, the rate of change would be $2\pi f$. This multiplied by L, the coefficient of self-induction, gives the induction of the circuit.

Too Much Pipe Friction—Why does a pump which will raise water with a vertical suction lift of 25 ft., fail to operate when connected to the top of the vertical suction pipe by a tight suction line extended horizontally a distance of about 300 ft.?

C. W. R.

Lifting by suction is accomplished by the pressure of the atmosphere which at sea level would balance a column of water about 33 ft. high; but in the operation of a pump with suction lift, in addition to the actual head overcome, the atmospheric pressure is employed in overcoming frictional resistances to the entrance of the water into the suction pipe, in overcoming air leaks, in creating velocity of flow, in overcoming pipe friction and friction of pump passages and in overcoming the pressure of air or vapor in the pump cylinder. Under the conditions stated, by extending the suction pipe 300 ft. additional resistance of pipe friction is introduced and a suction supply to the pump cylinder cannot be maintained because the sum of the resistances to flow have become too great to be overcome by the pressure of the atmosphere.

Efficiency of Hydro-Electric Plant—A hydro-electric plant has a direct-connected generator connected to the shaft of a horizontal water turbine. As shown by the sketch, the head water has an elevation of 190 ft. above the level of the tail water when the plant uses 50 cu.ft. of water per second, and develops 480 kw. What is the water horsepower and the overall efficiency of the plant?



B. J. L.

One kilowatt equals 737.3 ft.-lb. per sec., and the net output would be

$$480 \times 737.3 = 353{,}904 \text{ ft.-lb. per sec.}$$

As a cubic foot of water weighs 62.36 lb., the water used would be

$$62.36 \times 50 = 3118 \text{ lb. per sec.,}$$

and as the total head is 190 ft., there would be

$$190 \times 3118 = 592{,}420 \text{ ft.-lb. per sec.}$$

developed by the water.

As 1 hp. $= \frac{33{,}000}{60}$ or 550 ft.-lb. per sec., there would be developed:

$$\frac{592{,}420}{550} = 1077.1 \text{ water hp.}$$

The output of the plant being equivalent to 353,904 ft.-lb. per sec., and the work of the water being 592,420 ft.-lb. per sec., the overall efficiency of the plant operating under the conditions stated is:

$$\frac{353{,}904}{592{,}420} \text{ or } 59.73 \text{ per cent.}$$

Engineers' Study Course

Elementary Mechanics--VIII

LAST LESSON'S ANSWERS

31. Fig. 29 shows the magnitude and location of all the vertical loads and reactions acting on the crankshaft, when the piston of the engine is on the top dead center.

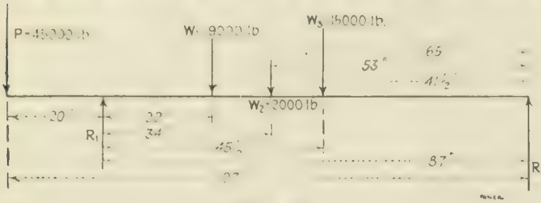


FIG. 29.

In this figure the forces are located both from the reaction R_1 and the reaction R_2. The purpose of this is to facilitate the taking of moments about either point, by clearly showing the moment arm of each force.

Fig. 30 shows the location of all the forces acting on the crankshaft when the piston is on the bottom dead center. In this case the direction of the force P is the reverse of what it was on the downstroke, and hence the reaction R_1 is downward instead of upward as before.

32. Take moments about the point R_1 (see Fig. 29). Thus,

$$-87 \times R_2 + 45\tfrac{1}{2} \times 15{,}000 + 34 \times 2000 + 22 \times 9000 - 20 \times 45{,}000 = 0$$

or $$87 \times R_2 = 948{,}500 - 900{,}000 = 48{,}500$$

and $$R_2 = 558$$

To determine R_1, take moments about the point R_2;

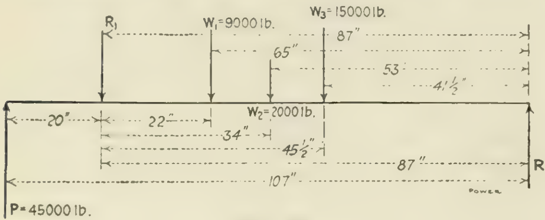


FIG. 30.

thus,

$$-41\tfrac{1}{2} \times 15{,}000 - 53 \times 2000 - 65 \times 9000 + 87 \times R_1 - 107 \times 45{,}000 = 0$$

or $$87 \times R_1 = 6{,}128{,}500$$

and $$R_1 = 70{,}442$$

33. Upstroke. Take moments about the point R_2 (Fig. 30).

Thus,

$$-41\tfrac{1}{2} \times 15{,}000 - 53 \times 2000 - 65 \times 9000 - 87 \times R_1 + 45{,}000 \times 107 = 0$$

or $$87 \times R_1 = 4{,}815{,}000 - 1{,}313{,}500 = 3{,}501{,}500$$

and $$R_1 = 40{,}247$$

To determine R_2, take moments about the point R_1; thus,

$$20 \times 45{,}000 + 22 \times 9000 + 34 \times 2000 + 45\tfrac{1}{2} \times 15{,}000 - 87 \times R_2 = 0$$

or $$87 \times R_2 = 1{,}848{,}500$$

and $$R_2 = 21{,}247$$

34. The accuracy of the results found in problems 32 and 33 can be checked by applying the law $\Sigma V = 0$; thus,

$$\Sigma V = 15{,}000 + 9000 + 2000 + 45{,}000 - 70{,}442 - 558 = 0$$

or $$\Sigma V = 71{,}000 - 71{,}000 = 0$$

This proves that the values of R_1 and R_2 as determined in problem 32 are correct.

For the upstroke, problem 33. $\Sigma V = 0$; thus,

$$\Sigma V = 40{,}247 + 9000 + 2000 + 15{,}000 - 45{,}000 - 21{,}247 = 0$$

or $$\Sigma V = 66{,}247 - 66{,}247 = 0$$

Hence the values of R_1 and R_2 are also correct.

35. The pressure of the steam on the piston, transmitted through the piston rod and the connecting-rod to the crank, does not produce any turning moment since there is no component of the connecting-rod thrust acting in the direction of motion of the pin.

CENTER OF GRAVITY

A body may be considered as made up of a series of small particles. The weights of all these particles form a system of vertical parallel forces, and the resultant of this system must evidently equal the sum of these forces or the total weight of the body. The point at which this resultant force or weight acts is called the *center of gravity* of the body. As commonly defined *the center of gravity of a body is the point through which the line of action of the weight of the body always passes.*

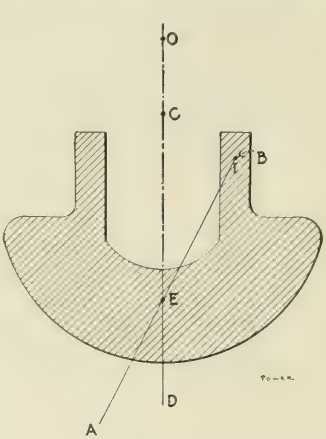


FIG. 31.

In the following discussion the term center of gravity will be abbreviated to the symbol *c.g.* If a bar of uniform cross-section is suspended by a rope attached at one end of the bar it is evident that the bar will hang in a vertical, and not in a horizontal position; or if the rope is attached to the center, the bar will probably assume a horizontal position. Hence a vertical line drawn through the point of suspension of a body must always pass through the *c.g.* of the body.

The *c.g.* of bodies which are symmetrical with respect to a given point, and are of uniform density, will be at the given point. Thus the *c.g.* of a sphere is at its geometrical center and the *c.g.* of a circle is at its center. The student can readily think of many more examples. Therefore, in many cases the determination of the *c.g.* is simply a matter of inspection. In the case of unsymmetrical figures the *c.g.* may be found experimentally by making a template of cardboard to represent the body to a given scale. Next suspend the template, first from one point and then from another, and in each case draw a vertical line through the point of suspension. The intersection of these two vertical lines will locate the *c.g.* of the template, from which the *c.g.* of the body can readily be found. Take, for example, the counterweight attached to the crank of certain forms of steam engines. Let the weight be of uniform thickness and its cross-section be of the form shown in Fig. 31, which is a template of the given weight. If the template be supported from the point *O* and the vertical line *CD* be drawn through the point of suspension, then the *c.g.* of the body will lie somewhere on this line. Likewise, if the template be suspended from the point *B* the *c.g.* will lie on the line *AB*. Therefore, the *c.g.* of the body will be found at the point *E* of intersection of the two lines *CD* and *AB*. This method is frequently used in the drafting room, as no computations are necessary.

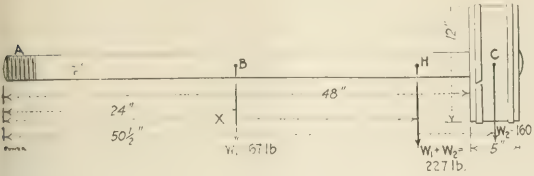


FIG. 32.

If a body can be divided into regular geometrical figures, such as triangles, squares and rectangles, the *c.g.* is best obtained by applying the law that the moment of the resultant (which is the total weight of the body) is equal to the sum of the moments of the other forces (the weights of each of the separate figures.)

Problem: At what point would a rope be attached to raise the piston and piston rod in Fig. 32 so that the rod will remain in a horizontal position?

Solution: The rope must be attached at the center of gravity of the piston and rod considered as a single body. This point is found as follows: The weight of the piston rod may be assumed as concentrated at its *c.g.*, which s evidently at the center of the rod, as at *B*. Likewise he weight of the piston is concentrated at its center *C* or the same reason. Let the unknown point be located t *H*, which is *x* in. from the point *A*, or end of the rod. ake moments about this point *A*.

Thus,

$$24 \times 67 + 50\tfrac{1}{2} \times 160 = 227 \times x$$

r

$$227\,x = 9688$$

nd

$$x = 42.7 \textit{ in.}$$

Problem: Fig. 33 shows the cross-section of a riveter rame. Locate the *c.g.* of this section.

Solution: This figure is symmetrical about its vertical xis, and hence its *c.g.* lies somewhere on the line *AB*, ay, at the point *H*, *x* in. from the line *CD*. Divide the ction into the three rectangles I, II and III. By inpection it is clear that the *c.g.* of each rectangle is at he point of intersection of the diagonals and also that he weight of each part is proportional to the area of the part. The moment of the weight of each section about any given point will then be proportional to the moment of the area. In dealing with problems of this kind the moments of the areas are usually taken in order to determine the *c.g.*

The *c.g.* of part III is located 9½ in. from the line *CD*, of part II 5¼ in. from *CD*, and of part I ¾ in. from *CD*. The area of part I equals 5½ × 1½ = 8¼ sq.in., the area of part II equals 7½ × ½ = 3¾ sq.in., and the area of part III equals 2 × 1 = 2 sq.in.

Now take moments of the areas I, II and III about the line *CD*. The sum of these moments must equal the moment of the resultant (total area).

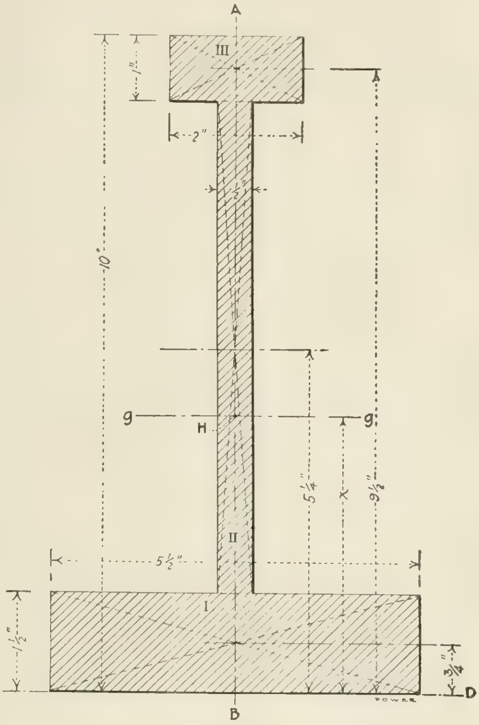


FIG. 33.

Thus,

$$\tfrac{3}{4} \times 8\tfrac{1}{4} + 3\tfrac{3}{4} \times 5\tfrac{1}{4} + 9\tfrac{1}{2} \times 2 = 14 \times x$$

or

$$14\,x = 44.87$$

and

$$x = 3.2 \textit{ in.}$$

STUDY QUESTIONS

36. Locate the center of gravity of a triangle.

37. Does the center of gravity of a body always lie within the body? Illustrate by an example.

38. A hole 4 in. in diameter is punched in a plate which is 15 in. square and of uniform thickness. The center of the hole is located 6 in. from either side. Find the *c.g.* of the punched plate.

39. An iron ball 6 in. in diameter is attached to a rod 2 in. in diameter. If the length of the rod from the end to the point of contact with the ball is 18 in., find the *c.g.* of the ball and rod considered as a single body.

40. The frustum of a right cone is 4 in. high; the diameter of the top is 4 in.; the diameter of the base is 8 in. Find the *c.g.* of the frustum.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Wal, I swan! Whatcha think of a passel of folks as gives an editor an invite to their power show, an' then up an' blacks his eye? 'Swhat they did to our Warren Rogers, over to Boston village lately. Some doin's! Ya-as, b'gum, they fetched little Warren over to the op'ry-house an' hed him alookin' into a tellyscope. Some darn cuss had smeared the eye-hole with lampblack an' blacked Warren's eye! Pesterin', b'gosh! Warren cal'lates 'twas Jas. Billbryan Myrick as pulled off the josh, an' he'll git Jas. if he has to set up till half-seven every night for a week. Looks like the Myrick place would be shy a farmhand come next Tuesday fortni't.

*

The centralization of power supply has an eloquent advocate in Samuel Insull, of the Commonwealth Edison Co. His company sold 840 million kilowatt-hours in 1913. In the meantime, chief, we'd better keep on plugging; Sammy won't be able to centralize us all for the next two or three years.

*

How the men in the moon, the Martians, built their canals is told by an astronomer who thinks he knows. Instead of excavating, as did poor deluded Goethals, they leveled everything in sight and erected walls on the sides of the canal. Wish a Martian would drop down this evening on the Washington folks and tell how the moon men disposed of the toll question.

*

In a certain monster office building the apparatus was the very latest word in automatic regulation; the management boasted of it, the village populace flocked to see it—and mebbe children cried for it. However, now and once in a while, there was a hitch, and things wouldn't automat worth a dum. One day the assistant chief, who was usually about as funny as a steam table, remarked: "There's only one regular way to get perfect automatic regulation. Some regular feller must invent a regulator to regulate the automatic regulator."

*

Looking backward 25 years, we find that "Power" said:

That $100,000 will be awarded the inventor who finds a practical way of utilizing the water power of Niagara Falls.

That the new Edison electric lighting station in Philadelphia has hit upon a novel plan. Eighteen 200-hp. engines are to be placed in the basement; over them, 36 dynamos; then the ash floor, and above, the boilers; the fourth floor will contain the coal.

That "One of our contemporaries announces 'The motor of the future. A condensable vapor to take the place of steam.'"

*

When it comes to war, the man behind the camera is the little red badge of courage. He goes into peril and hardship unflinching and unfaltering—and, perhaps because he is a non-combatant, he is lost sight of in our enthusiasm for the boys behind the guns.

*

Your Uncle Billy waxed eloquent to The Skipper, our fellow editor, anent the hardships of the war photographers. Skipper said it was no cinch to get pictures in a power plant, either. On a recent skirmish into Pennsylvania, he (200 pounds in the shade) had to scale a five-story building, had a new dollar derby sniped by a hidden pipe, his glasses were shot from off his face, and a hole burned in his panties. All of which seems to prove that Peace hath her damages no less destructive than War.

*

A mighty good little shop kink is the four-page monthly paper of Stevenson No. 44, of New York City. It is appropriately called "The 44 Booster." Its contents form a local message of optimism, announcements of coming events, joshes, etc. It can't be costly, and it's a live wire in keeping the members interested. The "Booster" could be imitated to advantage by many other locals. We get you, Stevenson, and more power to your journalistic elbow!

*

As to that "spill" of last week anent the Archibald boy who "invented the pressure," we thank 127 of our alert readers for sending us additional clippings this week. But the brass ring has been given to a Chicago child who is entitled to another ride, free, on the green zebra of our merry-go-round.

Isolated Plant Bests Central Station

By Fred S. Tinkham

About two years ago the management of the Y. M. C. A. in Cambridge, Mass., proposed to make additions to its building that would approximately double its size. Along with this change came propositions for the engineer who had been with them for several years. As usual, the agent of the central station was active. He, of course, maintained that the high efficiency of generating current at their plant enabled them to sell current for much less than it could be produced by a private plant. He also contended that if current was bought outside, a cheaper class of help could be employed for heating, etc., where if a private plant was operated, licensed men would be needed and at a higher wage.

The question was argued at length, and the central-station agent tried to show that his price of 5c. per kw.-hr. was better than could be obtained in the plant. His statements might have been convincing had not records been kept of the old plant for several years previous. These records were looked up and carefully gone over and with the records of the previous year were placed in the hands of a consulting engineer for criticism.

It was found that the current cost them less than 4½c. per kw.-hr., allowing the plant a credit for heating the building and paying overhead charges only on that part of the plant not necessary for heating. With the output doubled, the cost of production would be cheaper, so it was decided to install the extra equipment needed.

The present plant consists of two Ames center-crank, high-speed engines, one a 10x12-in. connected to a General Electric machine and the other a 12x13-in. connected to a Crocker-Wheeler generator; three 54-in. horizontal return-tubular boilers, one 12x5x36-in. deep-well pump with a capacity of 40 gal. per min. from a well 400 ft. deep, two National heaters, one large cylindrical-tank heater 10x5 ft. with a trombone coil which heats water for the building and shower baths, one 1½-hp. motor used to circulate the water in the swimming pool, boiler-feed pumps and a pump used when cleaning the bottom of the swimming pool.

The building is five stories high, 120 ft. front, 149 ft. deep and contains 11,866 sq.ft. of radiating surface, which is supplied with exhaust steam from the engines and pumps. When this is not sufficient, live steam is supplied through a reducing valve. During the coldest days but 3 lb. pressure is needed and the average for the season is about 1 lb. A Paul single-pipe system is installed.

The building has a swimming pool 60 ft. long and 20 ft. wide with a varying depth of 4 to 7 ft. It holds 55,000 gal. and is supplied by the deep-well pump. The water is heated by one of the National heaters and a constant temperature of 76 deg. is maintained throughout the day and a part of the night. Each morning an additional amount of water is supplied to compensate for loss over the spit rail and from cleaning the bottom of the tank. This additional water is sufficient to lower the temperature of the water from 76 to 72 deg., making a heat loss of 4 deg. on 55,000 gal. of water to make up daily except Sundays. During the year the water in the tank was changed 23 times, so that it was necessary to raise 22 deg. the temperature of 23 × 55,000 gal. of water.

For the year the wattmeters showed that 94,762 kw.-hr. were generated. At the central station's figure of 5c. per kw.-hr. the cost for current alone would be $4738.10. The expenses of the entire plant for the year ending Mar. 31, 1913, were as follows:

Fuel	$4305.00
Labor	2723.00
Oil	77.03
Waste	22.81
Packing	28.77
Water	53.71
Other expenses	579.67
Total	$7789.99

As this is the total operating expense of the plant a division must be made to determine the cost of producing current. From the labor charge of $2723, but $1161.81 is chargeable to power. From the $4305 for fuel a certain proportion should be subtracted for heating the building and heating water for building use and that of the swimming pool.

The heating of the building, located as it is and exposed on all sides, with considerable glass, is calculated on a basis of 22c. per sq.ft. of radiation per season, or a cost of $2610.52.

The total water used in the swimming pool during the year is

$$55{,}000 \times 23 \times 8.33 = 10{,}541{,}666 \text{ lb.}$$

This must be raised in temperature 22 deg. On a basis of 1 B.t.u. per degree per pound of water, 231,916,652 B.t.u. would be required.

Then making up the 4-deg. drop in temperature on 55,000 gal. daily except Sundays would require

$$4 \times 313 \times 55{,}000 \times 8\tfrac{1}{3} = 573{,}833{,}333 \text{ B.t.u.}$$

$$573{,}833{,}333 + 231{,}916{,}652 = 805{,}749{,}985 \text{ B.t.u.}$$

Using a coal with 14,000 B.t.u. per lb. and 60 per cent. boiler efficiency

$$805{,}749{,}985 \div 8450 = 95{,}923 \text{ lb.} = 47.9 \text{ tons of coal}$$

At $4.50 per ton the charge against the account for heating the water in the swimming pool would be $215.55.

Then this water has to be pumped from a well 215 ft. deep against an average head of 30 lb. Not less than 10,000,000 lb. of water are raised 285 ft. during the year, an equivalent of 2,850,000,000 ft.-lb. Allowing 15,000,000 ft.-lb. per 100 lb. of coal and a pump efficiency of 50 per cent., 38,000 lb., or 19 tons of coal, would be required. At $4.50 per ton the pumpage would amount to $85.50. Then

$$\$2610.52 + \$215.55 + \$85.50 = \$2911.57$$

Deducting this from the total fuel cost of $4305 leaves $1393.43 as the cost of coal chargeable to power.

The cost of the plant was $7000, but $4500 of this was paid for the old equipment and 80 per cent. has been already charged off for depreciation. This leaves $900 as the depreciated value and adding $2500 for the new equipment gives $3400 as the present value of the plant. Allowing 13 per cent. for fixed charges gives $442. Then the operating charges are as follows:

Labor	$1161.81
Fuel	1393.43
Fixed charges	442.00
Miscellaneous supplies (½ of total)	381.00
Total operating expense	$3378.24

The cost per kilowatt-hour would be

$$\$3378.24 \div 94{,}762 = \$0.0356$$

The central-station charge was

$$\$0.05 \times 94{,}762 = \$4738.10$$

so that under present conditions the station saved per year $\$4738.10 - \$3378.24 = \$1359.86$

No charge is made for several small uses of steam of which it is impossible to even estimate the quantity.

* * *

Errata—In the table accompanying the article on Working Up a Boiler Test, on page 593, of the issue of Apr. 28, Item 33 should read, "Item 20 ÷ Item 16, or Item 24 ÷ Item 22 = 8.23."

Item 38 is the efficiency of the boiler and furnace and Item 39 that of the boiler, furnace and grate.

Fourth National Textile Exhibition and Second National Power Show

The Fourth National Textile Exhibition under the auspices of the Textile Exhibitors' Association and the Second National Power Show by the New England Association of Commercial Engineers was held in the Mechanics' Building, Boston, Mass., Apr. 27 to May 2, inclusive.

During the two days' business session of the National Association of Manufacturers the textile industry was thoroughly discussed in relation to foreign trade prospects, which are considered bright, and the effects of labor problems and the tariff, which are thought bad for the cotton mills as a whole.

The business session was held in Paul Revere Hall. President Edwin F. Greene called the convention to order at 11 o'clock Wednesday morning During the session Arthur Tisdale Bradlee, of Chestnut Hill, was presented the 1914 medal in recognition of his contribution to the cause of the industry, a paper of high merit on "Investigations upon the Effect of Moisture in Testing Cotton Yarns and Fabrics"

Governor Walsh was present to extend the Commonwealth's welcome to the cotton manufacturers, and he made a short adress referring to legislation and transportation.

Among the speakers at the afternoon session were ex-Mayor Fitzgerald and Ralph M. Odell, of Washington. Papers were offered at the second, third and fourth sessions.

At the close of the annual meeting Thursday afternoon, Apr. 30, the following officers were elected: President, Albert G. Duncan; vice-presidents, William M. Butler and Grosvenor Ely, and five directors. Nineteen active and six associate members were elected.

Of the papers presented at the convention of interest to engineers was "Electric Power Contracts," by William L. Puffer. "Mill Steam Plants" was not read by the author, A. G. Hosmer, as he was unable to be present.

ELECTRIC-POWER CONTRACTS

In taking up the question of power contracts, Mr. Puffer was of the opinion that, whenever it appeared desirable for a manufacturer to compare the probable cost of producing his own power as against the purchase of it from a service corporation, there is difficulty on the part of the purchaser in understanding the terms used by the seller, because the contract agent begins to talk in what is substantially a foreign language.

It was pointed out that, generally speaking, there is no great difficulty in arriving at some idea of how many horsepower will be required to operate a mill and in estimating the probable amount of time in the year that the assumed horsepower will be used, which result is expressed in horsepower, and may or may not include a proper allowance for overtime, night work, short hours and partial time.

The horsepower year is an expression often used to give definiteness to a statement of the requirement of a mill, but the author gave several definitions which could be applied. A horsepower year might be:

Definition 1. Exactly 1 hp. steadily day and night throughout the year, or 1 hp. × 365 days × 24 hours equals 8760 hours' use of exactly 1 hp.

Definition 2. Exactly 1 hp. steadily day and night throughout the year except Sundays and, say, three holidays, or 1 hp. × 310 days × 24 hours equals 7440 hours' use of exactly 1 hp.

Definition 3. Exactly 1 hp. steadily for a 10-hour day for every day in the year, or 1 hp. × 365 days × 10 hours equals 3650 hours' use of exactly 1 hp.

Definition 4. Exactly 1 hp. steadily for a 10-hour day except Sundays and, say, three holidays, or 1 hp. × 310 days × 10 hours equals 3100 hours' use of exactly 1 hp.

Definition 5. Exactly 1 hp. steadily for an eight-hour day excepting Sundays and say three holidays, or 1 hp. × 310 days × 8 hours equals 2480 hours' use of exactly 1 hp.

The paper points out that if, instead of a heavy load, it fluctuated for a short time by, say 10 per cent. above and below the exact 1 hp., and that if the driving power were limited to exactly 1 hp., the average horsepower could not be operated, and it would be necessary to have an available capacity of 1.1 hp.

If the load never exceeds 1 hp., but because of the stoppage of some machine the full horsepower is not required all of the time, the condition would be more nearly the average man's idea of a horsepower year; this is indefinite because of the unknown amount and time the load falls off.

DEMAND AND LOAD FACTOR

Demand and load factor must be considered in mill-power propositions. Demand is the greatest use of power at any time; the load factor is the percentage which the actual horsepower-hours are to what they would have been if the demand had not been used continuously; or, the load factor is the percentage the average load is of the maximum.

Unfortunately, "load factor" has been used in connection with the day of eight, ten or twenty-four hours, a month or a year of different number of hours, consequently the term is dangerous in a contract unless carefully defined. This is so because no engineer has the means of measuring the actual number of horsepower hours his engine has developed. The best he can do is to take indicator diagrams at times assumed to represent the average load, and then try to estimate or guess the number of hours the load will be or has been used; even then he has no idea of the underload runs and the runs at odd times. The electrical engineer, however, has many simple and accurate methods and instruments which clearly show by charts, dials or pointers, any or all of the desired results.

The electrical terms "kilowatt" and "kilowatt hour" are now generally used in place of horsepower and horsepower hour, the electrical unit being almost exactly one-third larger.

Nearly all power prices are made up of the demand and the load factor charges, in a contract or rate sheet they are indicated by such expressions as "meter," "demand," "service," "readiness to serve," "primary," "first twenty-four hours' use of the demand" and special prices for the first given block of power, etc.

When power is transmitted by alternating currents, it is nearly always found that with the usual types of motors, lines and appliances, that there are times when the current actually flowing through the conducting system is not at all proportional to or commensurate with the transmitted energy. Under the changing conditions of the usual commercial service, this idle or false current varies from a negligible to an extremely serious amount.

The author said that the name given to the cause of this condition is "power factor." The power factor is the percentage ratio between the true energy and the apparent energy, and the true energy is always less than it would seem to be if judged by the current actually flowing. The more nearly 100 per cent. the power factor is, the better; it averages between 80 and 95 per cent. under good conditions, and under bad conditions it may fall to 50 per cent; when at 71 per cent., the current is twice what it would be at 100 per cent. power factor, and the capacity of lines, transformers and the like is taxed as heavily as it would be with two consumers having 100 per cent., yet the purchased kilowatt-hours are but those of one.

Every purchaser of power in any moderately large quantity should protect himself by the use of a continuously operating curve-drawing instrument, making a written record of some factor in connection with the supply of electricity which will be the most service in checking up his power conditions. These instruments are available for the recording of momentary conditions of any electrical quantity and, if properly installed, they produce a record that cannot well be disputed. For example, a curve-drawing demand meter would give a record of the power required, the time of starting, short hours, times of shutdowns and the falling off of the output toward the end of work hours.

There is a tendency to offer the alternative of metering all energy "on high tension service" at a seemingly attractive low rate. Such rates must be studied carefully to discover the effect of transformer losses, losses in wires and other apparatus which may of necessity be in use for many hours. Usually, small transformers can be substituted in place of the regular service ones during Sunday and the fourteen hours of night use.

All clauses which are worded so as to shift the responsibility for accidents or fires from the supply company to the purchaser should be examined critically and, if possible, struck out. It surely must be a part of the power company's responsibility to so arrange its devices that no dangerous conditions should be brought about on the purchaser's wires or premises, and it is a part of the purchaser's responsibility to see that everything on his side of the company's transformers is proper and safe and that all safety devices required by insurance or other authorities are installed and operative.

ONE-SIDED CONTRACT

Common sense and justice should be evident in power contracts, and no attempt made to handicap either party to the contract. At times, it happens that queer provisions are brought about by a combination of clauses which are in themselves not intended to injure.

The author mentioned a contract which he condemned because, if taken literally, the mill could never grow, as the company was to buy power up to a definite and final limit and was forbidden to build a plant of its own, make its own light or get it elsewhere, and all the electric lighting was expressly cut out of the contract. The power company did not have to give notice of refusal to continue the contract until the day before it expired. There were no offsets for poor service, loss of power, low voltage or low frequency. These things were not evident to the ordinary reader and probably were not purposely designed, and yet they were very definitely and carefully stated, partly in the body of the contract and partly in the fine print "conditions." As finally signed, all these matters were settled and arranged on an equitable basis.

Power Show

In connection with the textile exhibition was the "Power Show," the exhibits being displayed in the lower floor of the building. This department received its full share of interested visitors. Thursday, being Engineers Day, many engineers visited the exhibits, which were attractive, and in several instances showed new devices of interest to power-plant men. The booths were tastefully arranged and the attendance of visitors kept up well until the close of the show. The following firms exhibited at the power show:

LIST OF EXHIBITORS

Albany Lubricating Co.
American Oil Company
American Power Company
Ames, Bradford L.
Am. Steam Gauge & Valve Mfg. Co.
Anderson Company, V. D.
Anderson, George P.
Ashton Valve Company
Atwood & Morrill
Autoforce Ventilating System
Autogenous Welding & Equipment Co.
Austin & Doten
Badger & Sons Co., E. B.
Betson Plastic Fire Brick Co.
Blanchard, J. Henry
Buckeye Engine Company
Burgmann Asbestos & Packing Mills
Byers Company, A. M.
Cave Welding Company
Chapman Valve Mfg. Co.
Chesterton Co., A. W.
Climax Smoke Preventer Co.
Coppus Engineering & Equipment Co.
Dearborn Chemical Company
Diamond Power Specialty Co.
Dixon Crucible Co., Joseph
Durabla Manufacturing Co.
Eagle Oil & Supply Co.
Economy Lubricating Co.
Edward Manufacturing Co.
Electric Smelting & Aluminum Co.
Evans Mill Supply Co.
Falk Co., The
Foster & Sons Co., F. W.
Gardner Grate Company
Garlock Packing Company
Griscom Russell Co., The
Haines & Co., Wm. S.
Harrington Mfg. Co.
Harrison Safety Boiler Works
Harvey Company, Arthur C.
Hyland Mfg. Company, W. J.
International Engineering Works, Ltd.
Jefferson Union Company
Jenkins Bros.
Kelly & Company, Inc., T. P.
Keystone Lubricating Co.
Lagonda Mfg. Company
Lead Lined Iron Pipe Co.
Lieberknecht & Co., F. W.
Litchfield, J. M.
Locke Regulator Co.
Lunkenheimer Company.
Mason Regulator Company
Massachusetts Fan Company
McClave-Brooks Company
McLeod & Henry Company
Miller's Sons, Wm. P.
Monarch Steam Blower Co.
Nashua Machine Company,
"National Engineer"
National Tube Company
N. E. Association of Commercial Eng.
Nightingale & Childs Co.
Norristown Magnesia & Asbestos Co.
Open Coil Heater & Purifier Co.
Patterson Lubricating Co.
Perfection Grate Company
Philadelphia Grease Mfg. Co.
"Power"
Pratt & Cady Company, Inc.
Reynolds Oil and Supply Co.
Robinson & Son Co., Wm. C.
Rose, P. R.
Roto Company, The
Rogers Co., H. A.
Schaeffer & Budenburg Mfg. Co.
Schumaker-Santry Co.
Shaw Propeller Co.
Simplex Tester Co.
S. K. F. Ball Bearing Co.
"Southern Engineer"
Stone, Herbert E.
Strong, Carlisle & Hammond Co.
Texas Company, The
Thermograde Valve Co.
Under-Feed Stoker Co. of Am., The
United States Graphite Co., The
Vasil Fuel & Steam Systems Co.
Walworth Mfg. Company
Watts Regulator Company
Webster & Company, Warren

Coming National and State Conventions

The following is a list of the coming national and state conventions as fully as can be ascertained up to the present time:

NATIONAL CONVENTIONS

National Association of Stationary Engineers, Milwaukee, Wis.	Sept. 7-12
American Order of Steam Engineers, Baltimore, Md.	June 1-6
Universal Craftsmen, Council of Engineers, Cleveland, Ohio	Aug. 4-8
Canadian Association of Stationary Engineers, Ottawa, Ont.	July 28-30

STATE ASSOCIATION CONVENTIONS OF THE N. A. S. E.

Illinois, Peoria	May 20-22
New Jersey, Jersey City	May 28-30
Iowa, Des Moines	June 3-5
Kansas, Atchison	June 3-5
Kentucky, Louisville	June 3-5
Indiana, Indianapolis	June 10-12
New York, Rochester	June 11-12
Ohio, Akron	June 17-19
Pennsylvania, Philadelphia	June 19-20
Connecticut, Bridgeport	June 26, 27
New England States, Providence	July 9-11
Michigan, Muskegon	July 15-17
Missouri, St. Joseph	July 29-31
Minnesota, Minneapolis	Aug. 12-14
Wisconsin, Milwaukee	Sept. 4
Texas, Fort Worth	———
West Virginia, Clarksburg	———
California	———
Colorado	———

⁂

New Haven Engineers Meet

Aëronautics was the topic for discussion at the quarterly meeting of the New Haven Section, A. S. M. E., held at the Mason Laboratory, Yale University, on May 1. E. S. Cooley, chairman of the section, presided, and the afternoon session was given up to three papers: "A Review of Aëronautical Progress" (illustrated), by J. J. Long, of Brown University; "Fuels for Internal Combustion Engines," by D. B. Pangburn, of Sheffield Scientific School; and "Aëroplane Motors," by Prof. D. L. Gallup, of Worcester Polytechnic Institute. Also, J. A. Steinmetz discussed aëroplanes from the military standpoint.

At the evening session, Prof. Breckenridge presided, President Hartness, of the society, gave an informal address, and two regular papers were presented: "The Evolution and Status of Aëronautics," by Henry Woodhouse, editor of "Flying," and "Representative American Aëronautical Motors," by Howard Huntington.

⁂

National Gas Engine Association to Meet in June

The tentative program of the seventh annual meeting of the National Gas Engine Association, to be held in Chicago on June 24, 25 and 26, has been given out. This includes, besides the president's address, by R. A. Oglesby, and the reports of the various committees, the following papers: "Horsepower Rating and Standard Brake," by Prof. P. S. Rose; "Catalogs," by Prof. G. W. Munro; "Coöperating with and Assisting the Dealer," by G. M. Matsan, and "Heavy Oil Engines in Small Units," the author to be announced later. In addition there will be the usual entertainment features.

The committee invites suggestions from members for the improvement of the program.

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How Villa Paid for a Motor

The agent for the Westinghouse Electric & Manufacturing Co., at El Paso, Texas, sent a draft to the Pittsburgh office recently with a letter explaining the sale. General Villa, the Mexican Constitutionalist leader, bought a motor to be used in pumping water for a camp. Villa offered rebel scrip in payment and was informed that this was valueless in America. Villa then dispatched a squad to a nearby town, raided a gambling house, and returned with several bags of American gold. With this he paid for the motor.

⁂

Philadelphia's "Get-Together" Engineering Mass Meeting

The scientific and engineering men of Philadelphia are preparing for a big mass meeting on the evening of May 15 in the Continental Hotel roof garden. During an informal smoker, prominent engineers will give short addresses, and there will also be music and a general entertainment.

Some twenty national and local societies having fully 4500 members in and near the city will be represented. This is to be the first of a regular series of general meetings. No long program will be attempted, but rather a "get-together" meeting to inaugurate an engineering congress each year.

Among the speakers will be Dr. C. P. Steinmetz, the General Electric Co.; Walton Clark, the United Gas Improvement Co., and president of Franklin Institute; Dr. Humphreys, president of Stevens Institute of Technology, and James Mapes Dodge will act as toastmaster.

Members of the national engineering and scientific societies of other cities are cordially invited. The tickets are $2 each and are to be obtained from C. C. Tutwiler, 1630 Real Estate Trust Building; Dr. R. B. Owens, of Franklin Institute, or from the Engineers Club of Philadelphia.

⁂

Lomax, Ill., Power Plant

Lomax, Ill., recently signed a contract for the first unit of a power system. This system is to furnish light, heat and power for the entire new preplanned city of Lomax. Their buildings and plant are so constructed that the new units may be added without interfering in the least with the daily business of those already installed. While they will furnish steam heat to the factory district and to the Free Vocational University that is to be built, in any different district the power furnished will be largely electric. This first unit consists of two fire-tube boilers, 450 hp., and a Hamilton-Corliss engine, a generator, pumps, heaters, tanks, fire pumps for protection for the factory district, etc.

The contract was let to the Gale Installation Co., Chicago. The buildings will be erected by local contractors, the work for the foundations being well under way. The plant is being erected from private plans.

⁂

Railroads Must Stop Smoke Nuisance

Notice has been served on the railroads entering Pittsburgh by city council calling upon them to observe the smoke-prevention ordinance. The chief smoke inspector, J. W. Henderson, was instructed by the councilmanic committee on health to notify the railroads that within three months they must comply with the smoke ordinance, otherwise the ordinance to compel them to use smokeless fuel on locomotives would be passed. This ordinance temporarily was laid over.

The Pennsylvania R.R. had sent a communication to the health committee giving reasons why, in the opinion of its engineers, it would be impossible, unless at great expense, to comply with the proposed ordinance requiring the use of smokeless fuel. There also was a letter from Smoke Inspector Henderson showing that in other cities smokeless fuel is in use on locomotives, and that in Pittsburgh the Pittsburgh & Junction operates its shifting engines with smokeless fuel.

⁂

Massachusetts Heating and Ventilating Engineers Inspect New Theater

After the transaction of the business of the regular meeting in April and enjoying a banquet, the Massachusetts Chapter of the American Society of Heating and Ventilating Engineers adjourned to make an inspection of the heating and ventilating plant of the new Scollay Square Olympia theater which is the largest popular-priced vaudeville and moving picture theater in New England, seating 3200 people. This ventilating system is the most modern and complete system of any yet inspected in this vicinity. The owners have gone to much expense to make it a recognized public benefit.

The system was designed and supervised by the Richard D. Kimball Co. and consists of a fresh air supply for the theater proper and all public rooms, and a separate exhaust system for the main house, gallery, balcony, public rooms and dressing rooms. Outdoor air first passes through the primary Vento heaters in the heater room, which is under the main auditorium floor, through the Carrier air washers, then through the secondary heaters to a fresh air American blower discharging part of the air into the plenum space between the auditorium floor and the basement ceiling, also to the public rooms, the remainder being discharged into the plenum space under the balcony. The air then passes into the theater and is distributed through mushrooms located under the seats of the auditorium and the balcony floors, so that practically every person in the audience has an individual fresh air supply.

The air washer and fan systems are especially to be noted because they are equipped with all the necessary apparatus for keeping the air supplied to the theater at the proper temperature and humidity. The air is exhausted from the theater by means of three 18-inch propeller fans, one under the balcony, another under the gallery and the third in a penthouse on the roof, large grilles in the soffits of the balcony, gallery and main ceiling are connected to the fans by means of ample galvanized iron ducts.

Every effort was made to have the air of the public rooms and dressing rooms just as fresh as that of any other part of the theater. The air in all public rooms is changed at least 12 times per hour by a propeller fan. Large vent grilles are in the ceiling of the dressing rooms and connected to a powerful propeller fan under the stage and discharged outdoors.

The heating system is of the vacuum type. Two horizontal tubular 66-inch boilers with 16-foot tubes, equipped with smoke consumers and Smith settings, supply the steam required for this theater, and also for the large office building connected therewith and another adjoining theater. All direct radiators are concealed behind neat grilles and under Johnson service thermostatic control.

NEW PUBLICATIONS

THE FUELS USED IN TEXAS. By William B. Phillips and S. H. Worrell. Published by the University of Texas. No. 35 of the Scientific Service of the University's Bulletin.

Messrs. Phillips and Worrell frankly state that while Texas has enormous supplies of good and cheap fuels, it is not being utilized to the best advantage. Of the original supply of eight billion tons of coal, the production since 1895 has been thirteen million tons, merely scratching the surface, so to speak. Texas has a workable lignite area of 50,000 square miles, and yet in the last 19 years but eight million tons have been produced from an original supply of about 30 billion tons.

As compared with some other coals, say the authors, the Texas coals, while not of the best quality, have been used with excellent results, the greater part by the railroads. The lignite industry has rapidly increased, and the authors believe that on the establishment of large power plants, lignite will be used to good advantage.

Of the 16 chapters composing this pamphlet of 287 pages, chapters 2 to 5 treat of the location and the production of the Texas fields, coal composition, its analysis, the dry distillation, production and value of coal gas and of oil and water gas. Chapters 6 to 12 are devoted to lignite, its composition and preparation, its use under stationary boilers, the heating value of briquettes, and the recovery of byproducts in distillation. Chapter 14 gives the comparative efficiency of coal, lignite and petroleum products in Texas.

* * *

Illinois' Coal Production—Illinois is producing 62,000,000 tons of coal per year, more than one-eighth of all the bituminous coal mined in the United States. The safety of the miners and the efficiency of the mining methods employed are therefore matters of national concern. The department of mining engineering of the University of Illinois, the State Geological Survey, and the United States Bureau of Mines have coöperated during the past three years to study Illinois mining conditions. The information collected at 100 mines is published in district reports. In Bulletin No. 2, "Coal Mining Practice in District VIII (Danville)," by S. O. Andros, are discussed causes of accidents to miners in Vermilion and Edgar counties, loss of natural resources by wasteful methods of blasting and mining, use of steel and concrete as substitutes for timber in the mines and other phases of underground mining. The bulletin also contains a description of the methods of removing the overburden from a coal bed by steam shovel, a system of mining which has been highly developed in this district. Copies of the bulletin may be obtained by addressing State Coal Mining Investigations, Urbana, Ill.

* * *

In Valves and Pumps where water under high pressure attains a high velocity it has been a general experience that gray iron and steel are subjected to peculiar cutting action more marked when two dissimilar metals are in contact.

ENGINEERING AFFAIRS

At the Boston Engineers' Club, on May 13, Capt. Charles H. Manning and other well known engineers will be the speakers. The topic will be "Boiler-Room Practice."

Instead of the usual annual excursion, an outing and field day will be held on Sunday, May 31, by the Combined Associations of Engineers in the Borough of Brooklyn. The Combined Associations include Local Associations Nos. 8, 27, 41, 57, Melville Council No. 9 and the Modern Science Club.

An illustrated lecture on "Boiler-Room Practice," covering all the essential details of modern methods, will be given at the Modern Science Club, 125 South Elliott Place, Brooklyn, N. Y., on Tuesday evening, May 19, at 8:30. The speaker will be Charles H. Bromley. The club invites and welcomes all engineers and others interested in power-plant economy and operation to avail themselves of the opportunity to hear this interesting and instructive lecture.

On the evening of April 20 a delegation from the Brotherhood of Power Workers, Springfield, Mass., visited Middletown, Conn., and organized a local of the Brotherhood. It begins with 25 members, and has already planned an educational campaign in the shape of illustrated lectures. The new officers are, President, W. M. Stockwell; vice-president, H. S. Willows; treasurer, E. S. Lewis; financial secretary, W. Rasche; corresponding secretary, R. A. McKeon; recording secretary, F. E. Davis; conductor, H. E. Ackerley; doorkeeper, E. J. Johnson; trustees, R. A. McKeon, C. A. Chatman, W. Rasche; grievance committee, E. S. Lewis, T. E. McAlpine, L. O. Taylor.

The Detroit Engineering Society held its twentieth annual meeting and election of officers Apr. 17. Many of the past presidents of the society addressed the meeting. The following officers were elected for the ensuing year: President, H. H. Esselstyn; first vice-president, O. W. Albee; second vice-president, W. S. Blauvelt; secretary and treasurer, F. H. Mason. The society has a membership of 504, action on 47 applications for membership pending. A meeting was held May 1. L. A. Hawkins, research engineer of the General Electric Co., presented a paper on "Industrial Research."

The Mechanical Engineering Society of the Massachusetts Institute of Technology, Boston, Mass., held its dinner on the evening of Apr. 29 at the American House. The members had the opportunity of hearing several speakers of national reputation in mechanical circles, including Prof. William Kent, Charles T. Main, Prof. E. F. Miller, Prof. G. B. Haven and Prof. G. E. Russel.

OBITUARY

HARRY R. GILBERT

Harry Rush Gilbert, aged 68, manager of the Continental Works of the National Tube Works Co, Pittsburgh, Penn., died on Apr. 26 at his home in Beechwood Boulevard, that city.

PERSONALS

R. C. Cole has joined the staff of the pneumatic tool department of the Ingersoll-Rand Co., and has been stationed at the Chicago office.

A. P. Singer, formerly engineer at the Spy Run power station of the Fort Wayne & Northern Indiana Traction Co., has resigned to accept a position with the Tennessee Power Co.

E. S. Cooley, for several years mechanical engineer with the New York, New Haven & Hartford R.R., will leave to take up the position of commercial engineer with the B. F. Sturtevant Co., at its New York office.

E. F. Walker, formerly sales manager of the hydraulic department of the International Steam Pump Co., will represent the Eynon-Evans Manufacturing Co. in New York and vicinity, with an office at 170 Broadway.

POWER

Vol. 39 NEW YORK, MAY 19, 1914 No. 20

Candid Chats

The Forehanded Man

Ever save any money? Ever start down to the Home Savings Bank and, thrusting your bankbook through the paying teller's window, say: "Here we are again, Caleb"?

You never did this thing? Well, you've plenty of company. But you always *meant* to? Sure, until the time came to do it. You banked on "futures." That was all you really did bank, was it not?

Right this minute, perhaps, you are tucking away a twenty because your last spring's suit is plenty good enough—until next spring gets here. Then you buy a new one with your contemplated savings.

And you see where you can save twenty-five more this summer by sticking around home on this year's vacation, and just taking day-trips. It's a tight little sum you're piling up already—in your mind.

Then there's Mrs. Engineer. It ought to be easy, any time, for her to pry off thirty more by a little extra household economy (of course, she's never tried this before!) You can almost see the whole family lighting out for the savings bank with money you are yet to earn.

There's that early fall coal stunt, too. You remember how you always "saved" a nice wad on the winter's coal; the coming winter is always a mild one before it gets here. This is positive this time. Haven't the squirrels been ashamed to look a nut in the face? Aren't the birds lingering longer than they usually linger? And then, when winter does come, don't you usually buy more coal than last year?

Save? Oh, well, you may say you've lots of time to do that. Your job at the plant is good, anyway, for the next thirty years. In that case there is plenty of time—unless the boss intends to scrap the old "recips" and install turbines. Of course, he'll then say: "If you can run them, we'd like you to stay with us. If not—"

If not, you must look elsewhere. A few dollars in the savings bank will make this looking easier. If not—

It's great to be an optimist, it's good to *mean* to do things, it's fine to be a forehanded provider, but—

Are you?

Better give over *planning* the larger things and *do* a little one *now*! Persuade yourself that the crisp new five-spot you put in the bank today is a big sight more money on your book than the hundred you plan to put in out of next year's earnings.

Let this sink in deep. Do a little now, and get into the habit; then you'll keep on doing and getting.

South Power Station of the Blackstone Valley Gas and Electric Co.

By Warren O. Rogers

SYNOPSIS—A turbine plant in which there are four main units with the condensing apparatus installed in the basement. Revolving screens are used at the intake of the condenser tunnel, which pick up any floating debris and discharge it into a trough from which it is washed to one side. A Gantry crane of the latest design, capable of discharging to the yard or boiler-house bunker conveyer, handles the coal from barges. The station is tied in with three other steam and hydro-electric plants, and is the main distributing station.

⁂

The South turbine power station of the Blackstone Valley Gas & Electric Co.'s plant, Pawtucket, R. I., is tied in with another but smaller steam station, a small hydro-electric plant and a combined steam and hydro-electric plant. The distribution of current is from the South station.

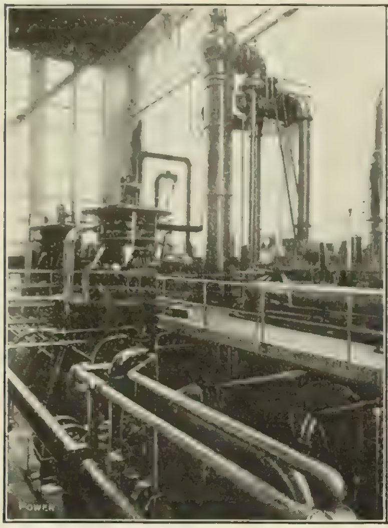


Fig. 1. Two Vertical 1500-Kw. Turbines and Jet Condenser

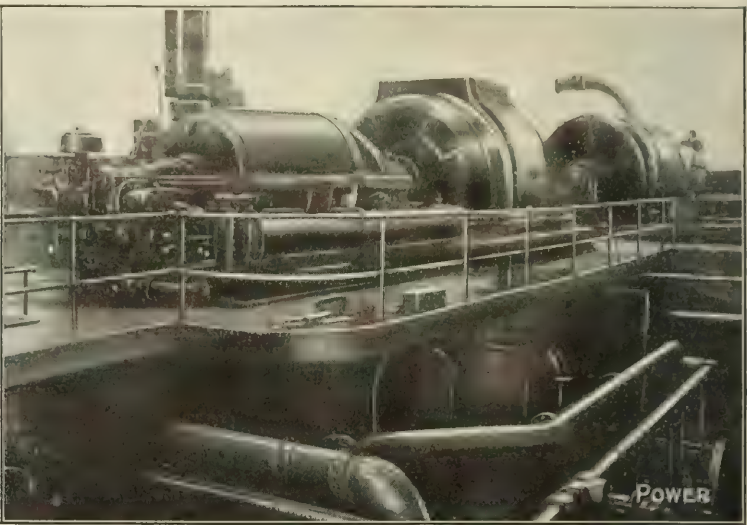


Fig. 2. Two Horizontal Turbine Units of 4500- and 12,850-Kv.-a. Capacity, Respectively

When the new station was built, in 1907, it consisted of one vertical turbine. A second unit of the same size was later installed. These main units are on hexagonal concrete foundations, which are nearly level with the floor of the turbine room. A metal grating around and between the unit makes it convenient for the operators. This arrangement affords ample basement room for all condensing apparatus, most of which is visible from the main floor on the switchboard side.

The Nos. 1 and 2 turbine units, Fig. 1, are each of 1500 kw. capacity and generate 2300-volt, three-phase, 60-cycle current at 900 r.p.m. with 175 lb. of steam. No. 1 turbine exhausts into a jet condenser. The condensing water runs into the low-head jet condenser under the influence of the vacuum and is removed by a double-acting, flywheel pump. A 12 and 24 by 18-in. steam-driven air pump is placed at the back of the foundation of the turbine it serves.

The second vertical turbine is connected to a barometric condenser, Fig. 1, which is installed next to the wall separating the turbine and boiler rooms. Condensing water is supplied by a 9x10-in. vertical engine-driven 14-in. volute pump. A 10 and 20 by 18-in. dry-vacuum pump is used for removing the air and uncondensed vapor from the system. As the condenser is in the turbine room, a short connection is made to the turbine. The tail pipe of the condenser terminates in a concrete-lined brick hotwell in the basement. A vacuum of 28 in. and over is carried on these units.

The third unit, installed about four years ago, of 4500-kw. capacity, is of the horizontal type and generates 2300-volt, three-phase, 60-cycle current at 1800 r.p.m. It is shown in the foreground of Fig. 2, on a level with the vertical units, and is surrounded by a concrete floor with a railing of pipe on the side next to the condenser basement.

This turbine is operated in connection with a "Type C" jet condenser which is so designed that a vacuum can be formed or recovered with a full load on the turbine without shutting off the steam going to the condenser and without the use of a stop valve in the main exhaust line.

All of the condensing apparatus is placed below the turbine; the exhaust opening is at the top and is connected to the expansion joint between the condenser and the turbine. With this arrangement, the steam travels about 3 ft. from the exhaust nozzle of the turbine before coming in contact with the condensing water.

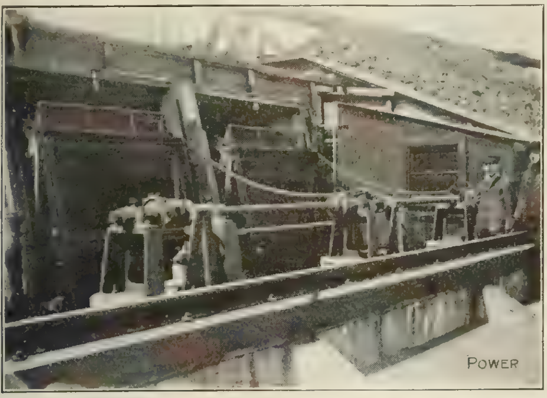


Fig. 3. Revolving Screens for Condenser Intake

In connection with the condenser there are two centrifugal pumps of different capacities mounted on the same shaft and driven by a single turbine. The larger pump, of the tri-rotor type, removes the water from the condenser, discharging it into the discharge tunnel. The smaller pump with a single impeller takes its suction from the common intake tunnel and discharges through two air-ejector nozzles into the discharge tunnel. This action removes the air from the air and water-separating chamber of the condenser, discharging it with the water. The discharge from this pump can be shunted into the condenser, forming a forced injection for priming the condenser should the turbine for any reason be running noncondensing and it is desired to operate condensing.

The injection water enters the condenser at one end, at the bottom of the head, the amount of water being controlled by a main injection valve. The water flows through several troughs with notched sides which run lengthwise of the condenser at a point above the center line. The notches permit the water to overflow in a series of thin streams, and as the end of the trough furthest from the inlet is at a lower level than the other end, the most water is delivered where the steam enters the condenser. The thin streams flowing over the sides of the troughs mingle with the entering steam and cause the water to break into a fine spray.

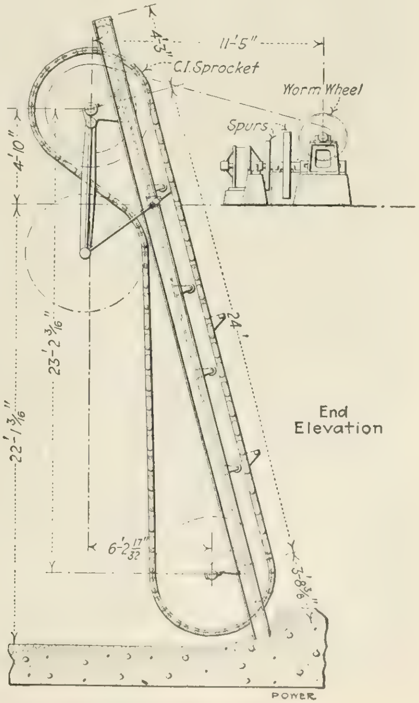
The air in the water, upon liberation, passes to an air chamber from which it is removed through the suction line to the air ejector. Such parts of the trough under the exhaust-steam nozzle are protected by baffle-plates. The spray, formed by the combination of water and condensed steam, falls through the steam, which has passed around the ends of the trough to the lower section of the condenser, into the water which is retained in the bottom of the condenser shell. The depth is regulated by the height to which the discharge pipe is carried up into the condenser. Air entering the condenser with the exhaust steam passes up between the troughs and through the water flowing over their sides into the air-collecting chamber and mingles with the air which came in with the injection water.

This condenser, in addition to the air-jet nozzle, is connected to a 12 and 30 by 18-in. dry-air pump in front of the concrete turbine foundation.

The fourth unit which has just been installed is of 12,850 kv.-a. and generates 2300-volt, three-phase, 60-cycle current, at 1800 r.p.m. This unit, shown at the far end of Fig. 2, exhausts into a Leblanc condenser under the turbine and between the concrete-foundation columns. The turbine-driven injection and air pumps are mounted on the same shaft.

Condensing Water

Condensing water was formerly taken from an intake tunnel which, owing to the tide variation, frequently caused trouble by an insufficient water supply. To overcome it, a new intake tunnel has been constructed 91 in. in diameter, and built so low that at low tide there is a depth of 8 ft. of water. The intake is protected against the entrance of leaves, grass and floating débris by stationary racks and by two revolving screens, Fig. 3. They



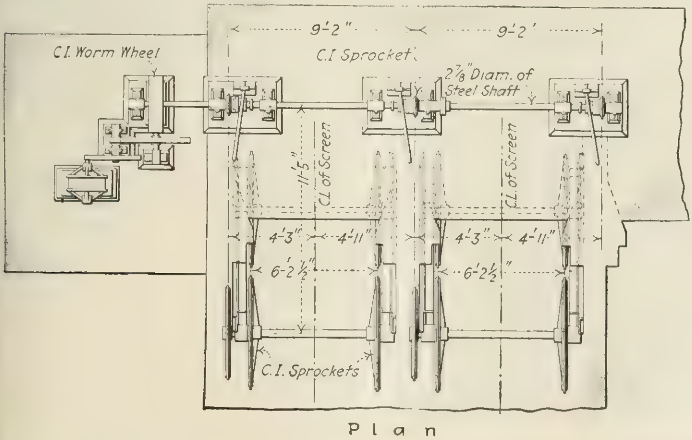


Fig. 4. Plan and Elevation of Revolving Screens for Condenser Intake

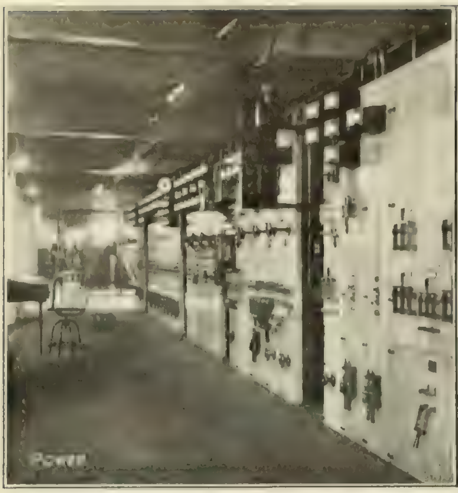


Fig. 5. Main Switchboard on Main Gallery

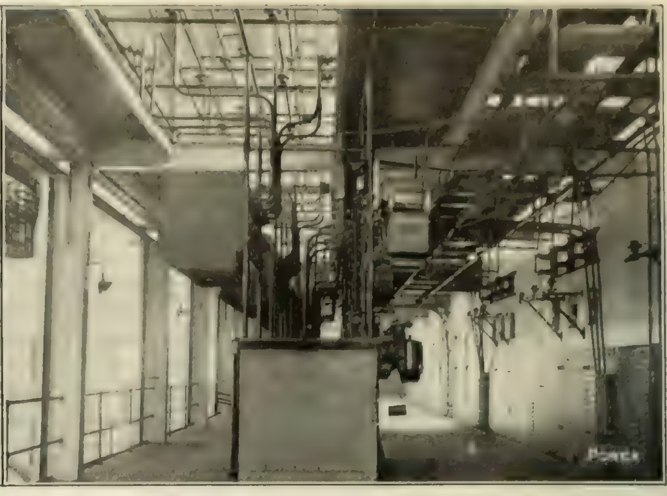


Fig. 6. Arrangement of High-Tension Busbars on Third Gallery

are operated by chains and sprocket wheels from a shaft which is driven by a worm gear and a 10-hp. motor, installed in the shed, at the right of Fig. 3. The shaft driving the screens has a clutch so that one screen can be cut out of service for repairs, etc. Fig. 4 is a detail drawing of the phosphor-bronze screens. Each is 6 ft. wide and is fitted with bronze wire baskets spaced 7 ft. apart, each 10 ft. 10 in. wide at the top and 5 ft. 6 in. long. The screens are of $\frac{5}{8}$-in. mesh wire. The screen sections are made of angle iron to which the wire mesh is secured, each attached to an endless chain at each end, composed of alternate long and short links, which run on large sprocket wheels. At the rear is a set of idler sprockets for adjusting the tension of the links. The

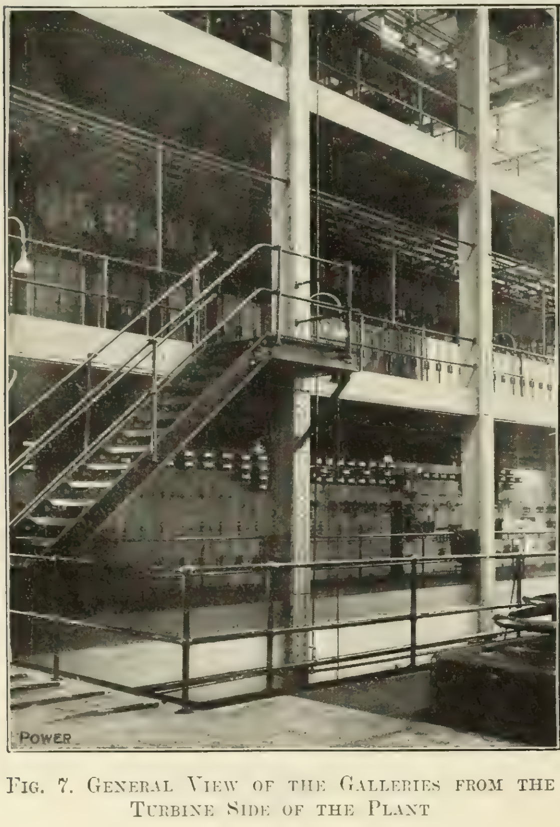


Fig. 7. General View of the Galleries from the Turbine Side of the Plant

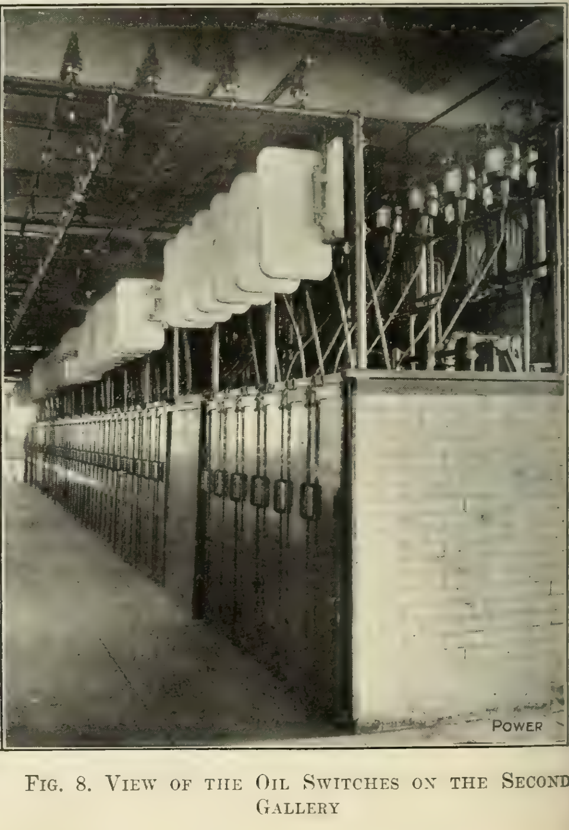


Fig. 8. View of the Oil Switches on the Second Gallery

speed at which the screen travels is 1 ft. per min., with the motor running at 720 r.p.m. As the screen revolves any foreign matter that has passed through the racks is picked up by the buckets, carried over the top of the sprocket and discharged into a trough at the rear of the screens.

In case the leaves and grass stick, provision has been made to wash them from off the screens by jets of water discharged through perforations in a 1½-in. pipe on the inside of the rear of the screens. This water is supplied by a 3-in., 10-hp., motor-driven centrifugal pump. All rubbish, after being deposited in the receiving trough, is flushed out of the way as the accumulation requires. During the cold weather, jets of steam instead of water are discharged through the perforated pipes, which prevents the formation of ice. The screens are housed at the rear and top, as shown in Fig. 3, and are supported on the open side by the beams which carry the sprocket wheels.

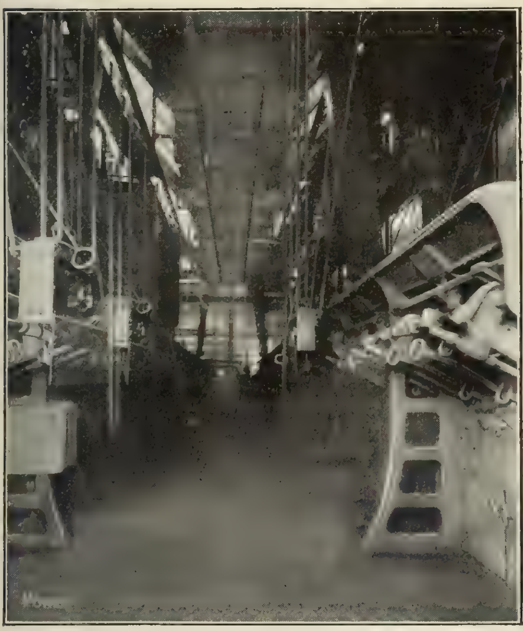


FIG. 9. VIEW IN BOILER ROOM, LOOKING TOWARD THE TURBINE ROOM

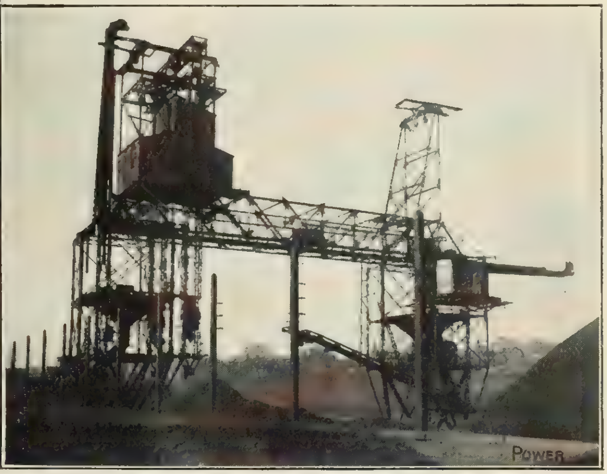


FIG. 10. GANTRY CRANE FOR UNLOADING COAL FROM BARGES TO THE YARD OR TO A BELT CONVEYOR

EXCITER UNITS

There are four exciter sets for the four generating units. One is of 35-kw. capacity, and is driven by a 35-kw. turbine at 3600 r.p.m., generating 125-volt current; another is a 40-hp., motor-driven, 125-volt, at 900 r.p.m.; the third, a 75-kw. turbine-driven set, at 3300 r.p.m.; the 75-kw. generator delivering current at 125 volts at 3300 r.p.m.; the fourth is a turbine-motor-driven set, the turbine being rated at 150 hp. On the opposite end of the generator shaft from the turbine is a 150-hp. induction motor. With this arrangement, the generator can be either turbine or motor driven.

PUMPS

The pump room is off the condenser basement under the boiler room, and contains two 6 and 2¼ by 10-in. duplex, outside-packed, step-bearing pumps which maintain a 400-lb. pressure on the step bearings of the two vertical turbine units. There is also an emergency motor-driven, triple-plunger, step-bearing pump. The three boiler-feed pumps are duplex, outside packed, with cylinders 12 and 7½ by 15-in. Artificial lighting is used because of the location of the pump room.

The switchboard, shown in Fig. 5, is on a level with the turbine floor but is separated from it by the condenser basement. At the far end are the mercury-arc rectifiers and arc-plug switchboards. On the gallery above the switchboard are the remote-control oil switches for the generators and feeder lines. On the gallery above these switches is another battery of remote-control oil switches and the high-tension busbars for the transformers and outgoing lines to the Woonsocket power house. A general view of the three galleries is shown in Fig. 7; the oil switches are shown in Fig. 8 and the arrangement of the high-tension busbars in Fig. 6.

BOILER ROOM

At the rear end of the turbine room is a passageway into the boiler room, which is at right angles to it. Here are installed ten 520-hp., water-tube boilers. Eight are equipped with one make of superheater and two have another. Each boiler furnace has a mechanical stoker, engine driven. Although there are four stoker engines, only two are used at a time, one for each battery of boilers, which are set in two rows with a firing aisle between. Fig. 9 is a view looking toward the turbine room. The boilers are served by two self-supported steel chimneys, one 12 and the other 16 ft. in diameter, and both 240 ft. high.

An electric truck used for removing the ashes runs directly under the ash hoppers for filling and then takes the ashes away for dumping.

Above the boilers is a coal bunker of 750 tons capacity. Over each stoker in the bottom of the bunker is a chain-operated coal valve discharging into four weighing hoppers with spouts, two for each side of the boiler room, traveling on light, overhead rails and propelled by a hand chain and sprocket.

Coal-Handling Apparatus

All coal is shipped to the plant in barges and unloaded by a gantry crane having two sources of discharge. Referring to Fig. 10, the crane, which runs on heavy rails, is equipped with two sets of crushing rolls. Coal is hoisted from the barge and can be discharged into the hopper above the right-hand rolls; after passing through them it goes to a short belt conveyor and is stored in the yard. If the fuel is for immediate use it is conveyed to the left-hand hopper and rolls and is discharged onto a belt conveyor, which runs beside the crane track next to the power house. The coal then goes to a bucket conveyor and is conveyed to the storage bin in the boiler house.

When coal is to be taken from the storage pile in the yard it is picked up by a clam-shell bucket and transferred to the long belt conveyor. As the crane has a long travel, a large coal-storage area is available. All operations and crane movements are by motor.

PRINCIPAL EQUIPMENT OF THE SOUTH POWER STATION OF THE BLACKSTONE VALLEY GAS & ELECTRIC CO.

No	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Vertical	1500 kw	Main units	175 lb. steam, 900 r.p.m., 2300 v., 3-phase, 60-cycle	General Electric Co.
1	Turbine	Horizontal	4500 kw	Main unit	175 lb. steam, 1800 r.p.m., 2300 v., 3-phase, 60-cycle	Allis-Chalmers Co.
1	Turbine	Horizontal	12,850 kv.a	Main unit	175 lb. steam, 1800 r.p.m., 2300 v., 3-phase, 60-cycle	Westinghouse Co's
1	Condenser	Jet, reciprocating	18x34x18-in	No. 1 turbine	Steam driven, 28-29-in. vac	Deane Steam Pump Co.
1	Pump	Air, reciprocating	12x24x18-in.	Jet condenser	Steam driven, 175 lb. steam	Deane Steam Pump Co.
1	Engine	Vertical	9x10-in.	Driving volute pump	Steam driven, 175 lb. steam	Henry R. Worthington
1	Pump	Volute	14-in.	Condensing water	Engine driven, 175 lb. steam	Henry R. Worthington
1	Pump	Air	10x20x18-in.	On barometric condenser	175 lb. steam	Henry R. Worthington
1	Condenser	Barometric		Vertical turbine No. 2	28-29-in. vacuum	Henry R. Worthington
1	Condenser	Jet		With turbine No. 3	28-29-in. vacuum	Allis Chalmers Co
1	Condenser	Leblanc	23	With turbine No. 4	28-29-in. vacuum	Westinghouse Machine Co.
1	Turbine	Terry		Condensate pump	175 lb. steam	Terry Turbine Co.
1	Pump	Triplex	12-in.	Condensate	Turbine driven	Allis-Chalmers Co.
1	Pump	Reciprocating	12x30x18-in.	Dry air, on jet condenser	175 lb. steam	Wheeler Condenser & Eng. Co.
2	Screens	Revolving	¼-in. mesh	Condenser intake	Continuous, motor driven	Exeter Machine Co.
1	Motor	Direct current	10 hp.	Revolving screens	720 r.p.m.	General Electric Co.
1	Motor	Direct current	10 hp.	Centrifugal pump	1700 r.p.m.	General Electric Co.
1	Pump	Centrifugal	3-in.	Screen water	1700 r.p.m.	
1	Turbine	Curtis	35 kw	Exciter set	3600 r.p.m., 175 lb. steam	General Electric Co.
1	Generator	Direct current	35 kw	Exciter	3600 r.p.m., 125 volts	General Electric Co.
1	Motor	Induction	40 hp.	Exciter set	900 r.p.m., 2080 volts, 3-phase, 60-cycle	General Electric Co.
1	Generator	Direct current	35 kw	Exciter	900 r.p.m., 125 volts	General Electric Co.
1	Turbine	Curtis	75 kw	Exciter set	3300 r.p.m., 175 lb. steam	General Electric Co.
1	Generator	Direct current	75 kw	Exciter	3300 r.p.m.	General Electric Co.
1	Turbine	Terry	150 hp.	Driving exciter	1175 r.p.m., 175 lb. steam	Terry Turbine Co.
1	Motor	Induction	150 hp.	Driving exciter	1175 r.p.m., 2300 volts, 3-phase, 60-cycle	General Electric Co.
1	Generator	Direct current		Exciter	1175 r.p.m.	General Electric Co.
1	Turbine	Curtis		Leblanc condenser	2500 r.p.m., 175 lb. steam	General Electric Co.
2	Pumps	Duplex	6x2¼x16-in.	Step bearing	800-lb. pressure	Henry R. Worthington
3	Pumps	Duplex	12x7½x15-in.	Boiler feed	175-lb. pressure	Henry R. Worthington
10	Boilers	Water tube	520 hp.	Main generators	175-lb. pressure, stoker fired	Babcock & Wilcox
8	Superheaters	Foster		On eight boilers	150 deg. superheat	Power Specialty Co.
2	Superheaters	Babcock & Wilcox		On two boilers	150 deg. superheat	Babcock & Wilcox
10	Stokers	Murphy		Boiler furnaces	Engine driven	Westinghouse MachineCo.
1	Crane	Gantry		Handling coal	Motor operated, intermittent	Robbins Conveyor Co.
1	Conveyor	Belt		Handling coal	Motor operated, intermittent	Robbins Conveyor Co.
1	Conveyor	Bucket		Handling coal	Motor operated, intermittent	Robbins Conveyor Co.

Miscellaneous

The pipe lines are not designated by the so called color system; the coverings are painted black, and the use to which the pipe line is put is painted on the covering in white letters, as shown in Fig. 2. For instance, all piping used for high-pressure steam is so marked, with an arrow pointing in the direction of the flow. Exhaust pipes are marked "Exhaust Steam"; water, oil and other pipes are marked according to the purpose for which they are used.

All transformers are in compartments under the main switchboard gallery on a level with the condenser basement. At one end of the engine room under the first gallery are two systems of air washing. One is a wet, the other a dry process. In the first, the air for cooling the turbine is passed through thin sheets of water before reaching the turbine; in the other, the air passes through cloth bags of special texture and design.

The chief engineer's office is at one end of the switchboard gallery, where there is also a waiting and small store room, washroom and toilet.

This plant was built by the Stone & Webster Engineering Corporation.

Production of Gasoline

By J. J. Blair

In the oil fields the crude oil either flows to the surface through the drilled wells or is pumped up. In either case, the wells have been driven to penetrate the strata which furnish the supply. This source is not an underground lake or pool, nor even a stream, but a very porous stone. In Pennsylvania it is sand, in Ohio it is limestone, in Kansas, sand, in Texas, limestone, and in the Western fields it is shale.

The oil in each instance is piped to a refinery where it is separated into several products. At each refinery there are a number of circular steel tanks holding from 50,000 to 75,000 bbl. of oil, and into these tanks the oil is pumped and held until needed. From these storage tanks the oil is pumped as required direct to the stills.

The stills are iron boilers usually about 12x30 ft. and are built in brickwork all in a row, resembling a battery of steam boilers. In the front end of each boiler there is a regular firebox, manhole, set of pet-cocks, and a thermometer. Those stills are fired by natural gas and are attended by unskilled labor.

The process of refining begins with the charging of the stills. The fire is turned up and distillation soon begins. From the vapor chamber on top of the boiler a pipe conveys the products of distillation to a condenser, consisting of a set of pipes from a freezing plant, run back and forth through a rectangular reservoir of water. From this condenser numerous pipes run to different parts of the refinery; some to storage tanks and others to departments where the product of the still is further treated. Paraffin is made in one department, axle grease in another, soap, and a score of different kinds and grades of lubricating oils, lighter oils and gasoline, in other departments.

Depending on the principle of fractional distillation, the stills give off the different products as the temperature of the oil increases. The portion that first distills over contains a large percentage of pentane, commercially known as rhigolene. The next portion consists of hexane-gasoline which represents only about 14 per cent. of the crude oil treated. The next fraction consists of heptane, which is collected until the temperature rises to about 110 deg. C. and is commonly known as naphtha. The next succeeding fraction is collected below 150 deg. C. and is known as benzine (not to be confounded with benzene, of coal-tar origin).

Coal oil, or the kerosene of commerce, is the next portion; it distills over between 150 and 300 deg C. This product is refined by agitating it with 1 or 2 per cent. of sulphuric acid; later on in the process, lubricating oils are obtained. The tarry residue is treated for vaseline and paraffin and the resulting asphaltum is often burned beneath the stills.

Unless the production of the crude oil had increased in proportion to the demand for gasoline within the past few years, this source of gasoline was destined to fail. Chemists, however, got busy, and were able to increase materially the production of gasoline from crude oil. Still another method of meeting the increased demand was discovered in the production of gasoline from natural gas, and as a result a number of plants are now in operation for this purpose. Instead of distilling off the gasoline, it is obtained by compressing and freezing the gas into the resulting gasoline.

Will Quizz, Jr.

SYNOPSIS—Will found a little difficulty with the Engineer's Study Course in understanding how the sum of the components of a force can be greater than the force itself. Chief Teller explains that he has confused force and work.

⁂

My dear Chief: While you have been away I have been trying to follow the Course on Elementary Mechanics in Power and got in trouble on the very first lesson in the issue of Mar. 24. It was stated that where a force of 200 lb. acts at an angle of 30 deg. to the horizontal, there is 173 lb. acting horizontally and 100 lb. vertically. Now, how can there be 100 lb. of wasted energy and 173 lb. of useful energy when the force applied is only 200 lb.?

The cosine of the angle is 0.866, which shows that 86 + per cent. of the force applied is going to useful purposes. Therefore,

$$1.000 - 0.866 = 0.134 = 13.4 \textit{ per cent.}$$

appears to me to be the energy wasted which would be

$$200 \times 0.134 = 27 \textit{ lb., about}$$

If we design a brace for a boiler it is worked out in this way. As, for instance, suppose we desire to stay a head and the brace is 1 sq.in. in cross-sectional area and is capable of standing a straight pull of 6000 lb. and be safe. If we place it at an angle of 20 deg. to the shell and still wish it to be capable of standing 6000 lb., we must use a stay enough larger to stand

$$6000 \times \sec. a = 6000 \times 1.0642 = 6385.2 \textit{ lb.}$$

and 385 lb. appears to me to be the wasted energy in this case. According to the mechanics lesson, it would be

$$6385 \times \sin a = 6385 \times 0.342 = 2184 \textit{ lb.}$$

I wish you would set me straight on this when you have time to write me.

All the boys send regards,

Yours respectfully,
Will Quizz, Jr.

Dear Will: Your letter received, and in answer I think I can quickly explain away your difficulty if you will just stop confusing in your mind energy and force. *Energy* is the capacity of a body for doing work, and *work* is the *overcoming* of a *resistance* through a *definite distance*. Forces which hold a body in a state of rest do no work on the body and, therefore, no energy is generated or expended.

The problem in Lesson I means that if a force of 200 lb. were acting on a body at an angle of 30 deg. with the horizontal, there would be an *effective* force of 173 lb. tending to move the body in a horizontal direction, and a force of 100 lb. tending to move it in a vertical direction. Thus, assume a heavy casting resting on the floor of a shop. Fastened to the weight is a rope which makes an angle of 30 deg. with the horizontal. Now, if there is a pull on the rope of 200 lb., it simply means that the effective force tending to move the body along the floor is 173 lb., and the force tending to raise the casting from the floor is 100 lb.

Your statement relative to the design of the boiler stay is correct as far as the force of 6385 lb. is concerned. Here the horizontal force or component is 6000 lb. and the force or pull in the stay is

$$6000 \times \sec 20 \textit{ deg.} = 6385 \textit{ lb.}$$

It is also true that the vertical force or component due to the pull in the stay is

$$6385 \times \sin 20 \textit{ deg.} = 6385 \times 0.342 = 2184 \textit{ lb.}$$

which force tends to shear off the rivets holding the stay in place, and there is no "wasted energy" as the stay does not move.

Further, your statement that 86 per cent. of the force applied is going to "useful purposes" is correct, provided you mean "useful purpose" in a horizontal direction; but it is also true that 34 per cent. of the force is going to "useful purpose" in a vertical direction. The lesson on "Resultants of Force," in the succeeding issue, Mar. 31, should help to clear away your difficulty.

Don't get discouraged, Will. Mechanics is a little hard at first, but once you get into it you will enjoy it and find it one of the most profitable studies an engineer can take up.

Remember me to the rest of the fellows, and see if you can't get them interested in this mechanics' course, too, for it would do them all good.

Yours as ever,
Teller.

How to Determine Type of Motor

By F. A. Annett

SYNOPSIS—Directions for determining by means of the leads whether a direct-current motor is shunt, series or compound wound. In very small motors the leads may be traced by the aid of a test circuit and lamp.

⁂

"What kind of a machine am I working with?" is a question that often confronts the electrician or engineer. In the medium- and large-size machines (2 hp. and up) this can usually be determined by inspection of the armature and field leads.

First, see if both the armature leads go to the external terminals, how many leads come from the field coils, whether they go to the external terminals; also, if there are small auxiliary poles (interpoles) between the main poles.

Assume a condition as in Fig. 1, where two leads come from the armature and two from the field coils which connect to four external terminals. If this machine is series wound, the armature and field leads will both be the same size, and of large cross-section. Sometimes, especially in small machines, one lead of the field is connected to one lead of the armature and only two terminals are brought out of the motor, as in Fig. 2. This does not alter the conditions, however.

If the machine is shunt wound, only the armature leads will be of large cross-section, while those of the field will be small, as indicated in Fig. 3. Also, the field terminals (lugs or connectors) will be small, while those of the armature terminals are large. On the series motor the field and armature terminals were large and of the same size. In some shunt motors a field and an armature lead are connected inside the machine and brought to the one terminal, as in Fig. 4. Again, in some very small machines the field coils are connected in multiple with the armature and only two terminals are brought out.

If the motor is compound wound, it will have two sets of fields. The series and the shunt coils are usually made up separately and placed on the polepieces, although in some cases the two coils are taped together before they are placed on the polepieces and look much like one coil, but they will always have four leads, two large and two small. These, together with the two armature leads, make six, which may be brought out to six terminals, as in Fig. 5; or one shunt and one series field may be connected to the same terminal, as in Fig. 6. Again, one of the series-field leads may be connected directly to the armature (brush), as in Fig. 7, making only four external terminals. As far as the number of terminals required to connect the motor to the ordinary starting box is concerned, the other series-field lead and one of the shunt-field leads may be connected together, making only three external terminals, as in Fig. 8. In general practice, however, compound motors have five or six terminals, as in Figs. 5 and 6.

The large terminals are those of the series field and the small ones those of the shunt field. This is very marked in the larger machines, the series field often being made of copper bar. The series field usually occupies from one-quarter to one-third the space on the polepieces occupied by the shunt-field coils, and may be placed either on the end of the polepieces near the armature or back against the frame.

If the machine is of the interpole type—that is, with auxiliary poles between the main poles—the interpole winding will always be in series with the armature. Like the series-field winding, it is of large cross-section as represented by the heavy lines in Figs. 9, 10 and 11. Referring to these illustrations, it will be seen that an interpole winding does not necessitate any additional terminals on the outside of the machine as one lead of the interpole is connected to one armature lead, leaving but one armature and one interpole lead to be brought to the outside terminals.

In the different classes of machines considered, the armature windings are the same, each machine deriving its name from the field winding and its connections.

One thing that can be kept in mind is that a series motor is seldom used except in railway, electric-vehicle and crane service. In some cases, however, they are used to drive small pumps and blowers, but these are usually limited to sizes of 2 hp. and less. It is on the small-size motors that it is the most difficult to distinguish the different types; for instance, by referring to Figs. 1 and 3, both motors have four terminals brought to the outside and in sizes below 2 hp. the leads from both the armature and field coils are the same size, so it becomes necessary to make some kind of a test to determine whether the machine is shunt or series wound. This can be done by testing with a lamp.

First, place one terminal of the test circuit on the brushes, and with the other terminal connect to the various motor terminals until the lamp is lighted, as will be the case when connected as in Fig. 12. This will indicate an armature terminal. If one side of the test circuit is connected to terminals F or F_1 while the other side is connected to the brushes, the lamp will not light, as these are the field terminals, but when the test is made to terminal A, the lamp will again light. This will indicate the other armature terminal of the machine.

After the armature terminals have been located, connect the test circuit to terminals F and F_1, as shown by the dotted lines. If the lamp lights dimly the machine is shunt wound, and if brightly, the machine is series wound; also, if it is shunt wound a severe spark will occur at the field terminal when the test circuit is broken. This will not be the case if the motor is series wound.

There is another way that the machine can be tested to find if it is shunt or series wound, in case a test lamp is not available. First, connect the field and armature in series, as shown in Fig. 2, and the remaining terminals to the line. If the motor is series wound it will start up with a strong effort and will soon reach a very high speed if not loaded. On the other hand, if it is shunt wound, if it starts at all, it will be with a weak effort and at a very slow speed. In most cases, it will not start at all, but if the armature is turned by hand it will be found to have a tendency to turn in one direction, and when the line switch is open, there will be a severe arc.

In case the machine is compound wound and connected as in Fig. 7, there would be four terminals appearing on

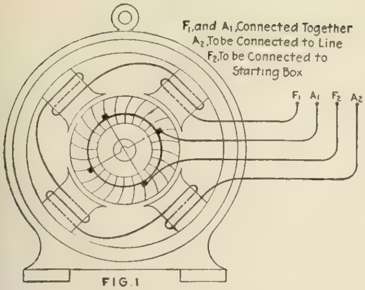

F_1 and A_1 Connected Together
A_2 To be Connected to Line
F_2 To be Connected to Starting Box

FIG. 1

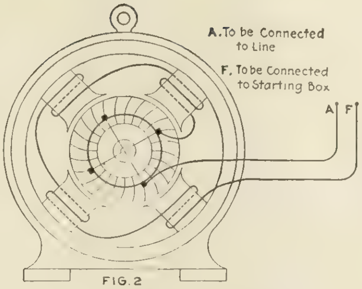

A. To be Connected to Line
F. To be Connected to Starting Box

FIG. 2

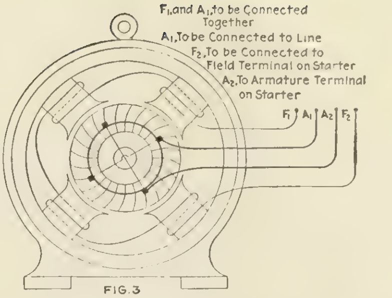

F_1 and A_1 to be Connected Together
A_1 To be Connected to Line
F_2 To be Connected to Field Terminal on Starter
A_2 To Armature Terminal on Starter

FIG. 3

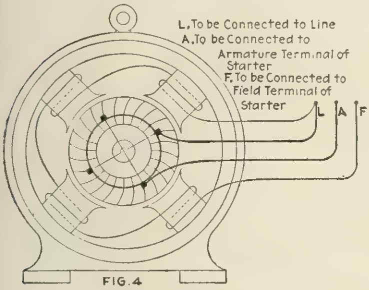

L, To be Connected to Line
A, To be Connected to Armature Terminal of Starter
F, To be Connected to Field Terminal of Starter

FIG. 4

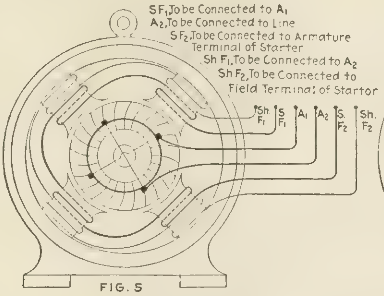

SF_1 To be Connected to A_1
A_2 To be Connected to Line
SF_2 To be Connected to Armature Terminal of Starter
Sh F_1 To be Connected to A_2
Sh F_2 To be Connected to Field Terminal of Startor

FIG. 5

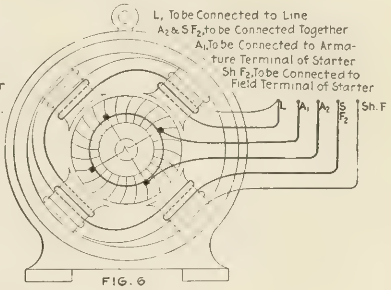

L, To be Connected to Line
A_2 & S F_2, to be Connected Together
A_1 To be Connected to Armature Terminal of Starter
Sh F_2 To be Connected to Field Terminal of Starter

FIG. 6

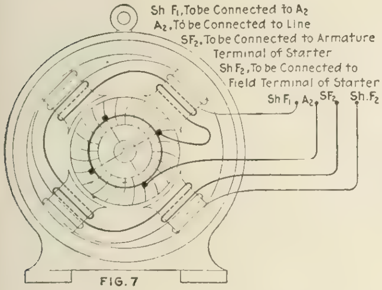

Sh F_1, To be Connected to A_2
A_2, To be Connected to Line
SF_2, To be Connected to Armature Terminal of Starter
Sh F_2, To be Connected to Field Terminal of Starter

FIG. 7

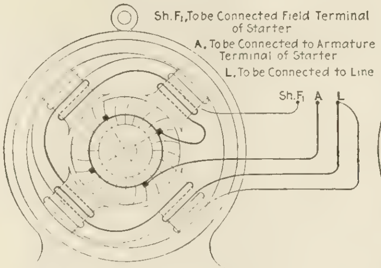

Sh. F_1, To be Connected Field Terminal of Starter
A. To be Connected to Armature Terminal of Starter
L. To be Connected to Line

FIG. 8

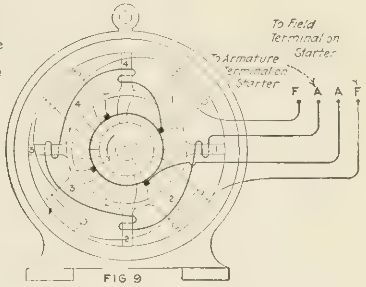

To Field Terminal on Starter
To Armature Terminal on Starter

FIG 9

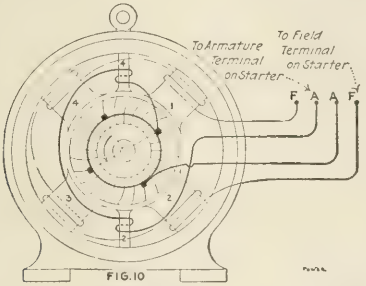

To Armature Terminal on Starter
To Field Terminal on Starter

FIG. 10

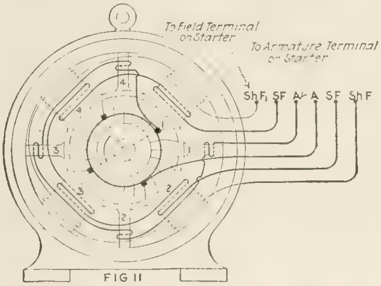

To Field Terminal on Starter
To Armature Terminal on Starter

FIG 11

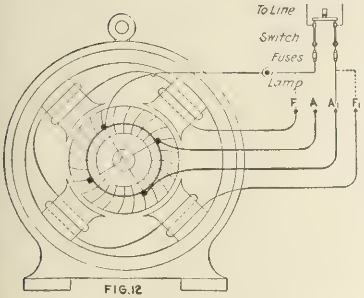


FIG. 12

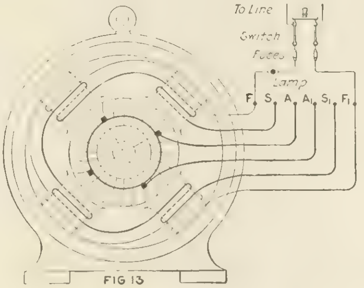


FIG 13

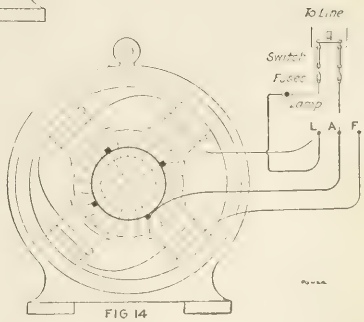


FIG 14

External Leads as Indicative of Type of Motor the outside, as in Figs. 1 and 3, so along with making the test as described above it will be necessary to see that one of the armature terminals does not connect direct to the field coils. The terminals of a compound motor with its leads brought out, as in Fig. 5, may be located as follows:

First, test for the armature terminals as described in connection with Fig. 12, then connect one side of the test circuit to one of the four remaining terminals, such as F in Fig. 13, and then with the other test terminal make connections first on one and then on another of the three terminals, such as F_1, until the lamp lights. The test lamp is connected to the field winding shown in fine lines which indicates it is the shunt, and in that case the lamp will burn dimly, due to the high resistance of the field coils, and when the circuit is broken, a severe arc will occur as described for the shunt motor. This leaves two remaining terminals to be tested. When the lamp is connected to them it will burn brightly for the series field always has a low resistance. This is also true of the armature.

When one side of the armature and one shunt-field lead are connected to the same terminal, as in Fig. 4, and it cannot be seen just what terminals the leads run to, a test can be made as follows: First, disconnect one armature lead at the brushes or raise the brushes from the commutator. In Fig. 14, one armature lead is shown disconnected from the brushes. Connect one side of the test circuit to this armature lead. With the other side of the test circuit, test the outside terminals until the lamp lights. It will burn brightly if connected to terminal L, whereas, if the test circuit is connected to terminal F instead of L, it will burn dimly, for now the field is in circuit. When the lamp burns brightly, it indicates that the armature lead goes direct to terminal L and when dimly that the field is connected to L and F. If one side of the test circuit is connected to the brushes and the other to terminal A, it will again burn brightly, but if one test wire is allowed to remain on the brushes and the other is placed on F or L, the lamp will not burn; this will indicate that the armature lead alone connects to terminal A.

In a great many cases the manufacturers mark the terminals, and in most cases these marks can be relied upon as being correct when the machine comes from the factory, but if the machine is repaired it is not always in reliable and careful hands, and in some cases these markings are mixed up, consequently, the safest and surest method is to test the machine before it is connected up.

* *

A Comparison of Boiler Standards

By J. W. F. Macdonald

While there has been considerable activity during the past few years in the United States as to the construction of steam boilers, it is interesting to note that a similar condition has existed in Canada, and already four provinces are enforcing rigid regulations governing such construction. In Alberta, Saskatchewan and Ontario the wording of the regulations is nearly identical. As to their application, some comparisons are here made with the rules of the state of Massachusetts and the different methods in treating details noted.

Approval and Registration of Designs

The rules of the Canadian provinces named state that before beginning the construction of any boiler, three blueprints of the complete shop-working drawings, with specifications in duplicate, must be submitted to the Department of Steam Boiler Inspection by the manufacturer for approval of the pressure and design, which must comply in all cases with the regulations. This applies as well to such fittings as stop valves, water gages and gage cocks, pressure gages and blowoff valves, etc. Approval will be given or corrections pointed out in the order the applications are received by the department, and the manufacturers are advised accordingly.

When finally approved, each particular design is given a registration number for each province and any number of boilers may be built according to the drawings of the design. In addition, each boiler shipped into the province must be accompanied by a copy of the approved specifications and an affidavit of the boiler-shop foreman, stating that the specifications have been carried out.

While the Massachusetts rules refer to some special cases which can be taken to the Board of Boiler Rules for approval, the inspection department does not make a practice of approving detail drawings, leaving it to the manufacturer to interpret the rules. While some delay may be caused awaiting the approval of new designs, according to the Canadian custom, it has, however, many advantages as it brings the inspector and the manufacturer in closer touch on questions of design and avoids any possibility of misinterpretation of the requirements, a condition which will invariably exist even with the most carefully worded regulations. Again, once a design has been approved, the manufacturer is assured that his boiler will be accepted if he follows his drawings and the workmanship is up to standard. Furthermore, as a fee of from $5 to $10 is required for approving and registering each design, it also has a tendency toward standardizing, using as few designs as possible.

Stamping and Identification

In Massachusetts each boiler must be stamped "MASS STD" with the name of the manufacturer, in full or abbreviated, and the firm's serial number. In Canada, in addition to the above details, the stamping must include the provincial letter and registration number of design, the lowest tensile strength of any shell plate in the boiler, with "S" for steel and "I" for iron; the name of the plate manufacturer and the date of construction, the latter giving the day of the month, numerical order of the month and last two figures of the year. The location of the stamp is practically the same in both cases. A sample stamping would be as follows:

In Massachusetts

MASS STD
976
I E W

In Alberta, Canada

International Engineering Works, Ltd. 78
A-563
57000-S
Lukens Iron and Steel Co.
16. 3. 14.

In addition, in Canada all new heating boilers must be stamped "For Heating Purposes Only" in some conspicuous place.

FACTOR OF SAFETY

In Canada, the value used for the factor of safety varies over a wide range to suit different conditions and methods of construction. A base value of 4.5 may be used when the following conditions are complied with: The cylindrical shells of boilers must be made of the best material (either iron or steel), with all holes drilled in place from the solid plate, the plates afterward taken apart and the burrs removed. The longitudinal seams must be fitted with double-butt straps each at least five-eighths the thickness of the plate they cover, the seams being double riveted with at least two rows in double shear and having an allowance of not more than 75 per cent. over that of single shear.

The circumferential seams must be so constructed that the efficiency is at least one-half that of the longitudinal seams. The boiler must also be inspected during the whole period of construction by an authorized inspector.

When the foregoing conditions are not complied with, an addition must be made to the base value (4.5), according to the conditions in the following scale:

(a) Add 0.10 when the holes in the longitudinal seams are fair and good, but drilled from the solid out of place after bending edges of plate.

(b) Add 0.20 when the holes in the longitudinal seams are fair and good, but drilled from the solid out of place before bending edges of plate.

(c) Add 0.20 when the holes in longitudinal seams are fair and good, but punched after bending edges of plate and reamed after assembling.

(d) Add 0.30 when the holes in longitudinal seams are fair and good, but punched before bending edges of plate and reamed after assembling.

(e) Add 0.07 when the holes in the circumferential seams are fair and good, but drilled from the solid out of place after rolling plates.

(f) Add 0.10 when the holes in the circumferential seams are fair and good, but drilled from the solid out of place before rolling plate.

(g) Add 0.10 when the holes in the circumferential seams are fair and good, but punched after rolling plate and reamed after assembling.

(h) Add 0.15 when the holes in the circumferential seams are fair and good, but punched before rolling plate and reamed after assembling.

(i) Add 0.70 when the longitudinal seams are not fitted with butt straps, but are lapped and double riveted.

(j) Add 0.50 when the longitudinal seams are not fitted with butt straps, but are lapped and triple riveted.

(k) Add 0.60 when the longitudinal seams have only single butt straps and are double riveted.

(l) Add 1.00 when in the longitudinal seams any description of joint is used which is only single riveted or where double butt straps are used and only row of rivets is in double shear.

(m) *Add 0.50 when the holes or rivets in longitudinal seams are not fair and good.

(n) *Add 0.20 when the holes or rivets in circumferential seams are not fair and good.

(o) Add 0.40 when the holes in any seams are not properly spaced in crossing.

(p) *Add 0.40 when the material is doubtful and not properly stamped in accordance with the regulations.

(q) Add 0.50 when the joints are not close fitting and the plates are open when the boiler is finished and the workmanship unsatisfactory.

(r) Add 0.50 if the boiler has not been inspected by an authorized inspector during the whole period of construction in accordance with the regulations.

(s) When any boiler has been subjected to overheating, strains by forcing, crystallized by age or otherwise impaired, the factor of safety shall be increased according to the discretion of the inspector.

When marked "*," the inspector may, according to circumstances, increase the factor given and in the event of satisfactory information not being obtainable, the inspector shall use a basic factor of safety of five with such additions as his judgment may dictate.

In the foregoing (a), (b), (c), (d), (e), (f), (g), (h) must be used separately but may be added, when justified, to either (i), (j), (k,) (l), (m) or (n) separately and to (o), (p), (q), (r) separately or to the four latter when calculating the efficiency of a joint.

To those who are accustomed to the Massachusetts or similar rules, such a variable value for the factor of safety will appear complicated, and instead of providing for such a number of conditions under which a boiler may be constructed, it will appeal to many engineers and inspectors that it is better to demand a standard form of construction in the details referred to and use a fixed factor of safety for new construction. The Massachusetts rules fix this value as *five,* but give specific requirements as to the drilling or reaming of rivet holes, limitations of lap seams, properties of material, etc. Poor workmanship is, of course, a feature which the most rigid rules cannot wholly overcome, and, although section (q) in the Canadian rules is provided for that purpose, it becomes a question of the judgment of each inspector, and as different men will have different ideas, the rulings made will be likely to vary more or less.

RIVETED JOINTS

The Canadian rules cover the design of riveted joints in much greater detail than the rules of Massachusetts, which refer to methods only for calculating the efficiency, leaving the design to the manufacturer.

The pitch of the rivets is limited by the formula

$$P_m = (C \times T) + 1\tfrac{5}{8}\ in.$$

where

P_m = Maximum pitch in inches of the rivets immediately inside the calking edge;

T = Thickness of the plate in inches;

C = Constant, applicable from Table 1.

TABLE 1

No. of Rivets in One Pitch Inside the Calking Edge	Constant for Lap Joint	Constant for Double Butt Joint
1	1.31	1.75
2	2.62	3.50
3	3.47	4.63
4	4.14	5.52
5	....	6.00

For example, in a triple-butt joint, using ½-in. plate, the maximum pitch of rivets inside the calking edge would be

$$P_m = (3.50 \times \tfrac{1}{2}\ in.) + 1.625\ in. = 3.375\ or\ 3\tfrac{3}{8}\ in.$$

In addition to limiting the pitch, formulas are also given for determining the minimum distance between the rows of rivets—that is, the transverse spacing. Such limitations all tend toward similarity of design among different manufacturers and discourage the use of freak designs. Chain-riveted joints are prohibited by the Canadian regulations, which allow for staggered types only. The number of rows of effective rivets is limited to three, whether in lap- or butt-strap construction; consequently the ordinary form of quadruple butt joint now in such general use in American practice is not allowed.

For calculating the efficiency of joints, the method of procedure is somewhat different, although the formulas are all similarly derived. In Massachusetts, the joint has to be calculated to find the actual pull required to rupture a repeating section by all possible methods of failure.

In making these calculations a fixed value of 42,000 lb. per sq.in. is given for single shearing of steel rivets and 78,000 lb. per sq.in. for double shearing. For the tensile strength of the plate, that stamped on the plate is to be taken, a value which may vary from 52,000 to 62,000 lb. and still be within the limits of the required physical properties. There does not appear to be any reason why the shearing strength of the rivets should not vary within certain limits just as well as the tensile strength of the plate; consequently it does not seem consistent that one value should be fixed and the other be variable. In the Canadian rules, instead of using actual values for tensile and shearing strength, a ratio is given between the two, the value of which depends on the material used. For example, when using steel plates and rivets

$$\frac{\textit{single shearing strength of rivets}}{\textit{tensile strength of plate}} = \textit{a constant} = 0.7$$

for steel plates and rivets. This appears to be a more consistent method, and has, in addition, a further advantage of simplifying the formulas in their application. The double shearing of rivets is taken as 1.75 times the value of single shearing; consequently rivets in double shear are always expressed in terms of rivets in single shear. The crushing strength of material in plate and rivets given as 95,000 lb. per sq.in. of projected area in the Massachusetts rules is not referred to in the Canadian regulations.

STAYED SURFACES

In the Canadian rules, the maximum stress allowable on flat surfaces shall be determined by the following formula: All stayed surfaces formed to be a curve the radius of which is over 21 in. are to be considered as flat surfaces:

$$\textit{working pressure} = \frac{C \times t^2}{p^2}$$

where

t = Thickness of plate in sixteenths of an inch. Where doubling plates are used, for t take 75 per cent. of the combined thickness of both plates;

p = Pitch of stays in inches when equally spaced in both directions;

C = Constant varying from 112 to 200, depending on conditions which take into account the style of staying used—that is, screw stays riveted over; screw stays with nuts; through stays with nuts inside and outside of plates; through stays using nuts or doubling plates, the latter having a thickness at least equal to that of the plate; through stays for plates stiffened with angle or tee bars.

For screw stays, the Massachusetts rules use the following formula:

$$\textit{working pressure} = \frac{C(t + 1)^2}{S^2 - 6}$$

where

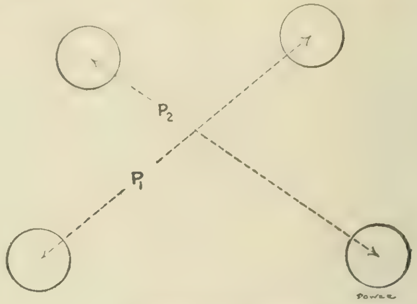
C = A constant = 66;

t = Thickness of plates in sixteenths of an inch;

S = Pitch of stays in inches.

For screw stays the Canadian formula will not give as great a pressure on thin plates, but will allow a greater pressure on thick plates. For example, $\frac{5}{16}$-in. plate, with stay-bolts pitched 5 in. on centers, is allowed a working pressure of 112 lb. in Canada and 125 lb. in Massachusetts, while $\frac{1}{2}$-in. plate with stay-bolts 7 in. on centers is allowed a working pressure of 156 lb. in Canada and 121 lb. in Massachusetts. No special provision is made in the Massachusetts rules for stays with nuts and washers or for the use of doubling plates. The latter is a convenient method of stiffening irregular flat surfaces and in many cases can be used to great advantage, particularly on the Scotch type of boilers.

The Canadian rules also make special provision for unequal pitches, thus where l = the pitch of stays in inches in one row and w = the distance in inches between two rows, then $\frac{l^2 + w^2}{2}$ is to be taken instead of p^2. Also, in cases of irregular staying, such as shown in the illustration



IRREGULAR STAYS

$\frac{(P_1 + P_2)^2}{8}$ is to be taken instead of p^2.

For the maximum working stress on stays, the Canadian rules allow 5000 lb. per sq.in. for welded-iron stays and 7000 lb. per sq.in. for iron stays without welds. For steel stays less than 1½ sq.in. of net sectional area, 8000 lb. per sq.in. is allowed, and for 1½ sq.in. or over of net area, 9000 lb. per sq.in. Steel stays must not be welded in any way.

The Massachusetts rules allow working stresses as given in Table 2.

TABLE 2

Type of Stay	Material	Maximum Allowable Stress per Sq.In. Up to and Incl. 1.227 Sq.In. of Net Area, Lb.	Maximum Allowable Stress per Sq.In. Over 1.227 Sq.In. of Net Area, Lb.
Head to head or through	Weldless mild steel	8000	9000
Head to head or through	Weldless wrought iron	7000	7500
Diag. or crowfoot	Weldless mild steel	7500	8000
Diag. or crowfoot	Weldless wrought iron	6500	7000
Head to head through diag. or crowfoot	Welded steel	6000	6000
Screw staybolts	Mild steel or wrought iron	6500	7000

For any diagonal stay, the Massachusetts rules do not directly take into account the angle which it makes with the supported surface, but instead reduces the allowable working stress from that allowable on direct stays, as noted in the table. For such stays, the Canadian rules allow only a stress equivalent to the allowable direct stress multiplied by the cosine of the angle made with the shell, this angle not to exceed 30 deg. Butt welding of the crowfeet or palms ends to the stays is prohibited. Another important point not covered in the Massachusetts rules is that the rivet area for attaching stays of all kinds to a head shall aggregate 20 per cent. greater than the stay area; also, when through stays are attached to angle or tee bars by a bolt or pin in double shear, such bolt or pin need only have an area of 75 per cent. that of the stay.

In staying the segments of the head above the tubes in horizontal return-tubular boilers or any similar design, the Massachusetts rules assume that the outside of the head is self-supporting for a distance of 3 in. in from the edge, it is also supported by the tubes for a distance of 2 in. from its edge. This is irrespective of the thickness of the plate, the radius of curvature of the flange, or the working pressure.

In the Canadian rules the distance in from the edge of the flange, which is considered self-supporting, is taken as

$$\frac{1}{2}\sqrt{\frac{112 \times t^2}{B}}$$

or the radius of curvature of the head flange, whichever is the greatest. For the support given by the tubes the distance from the edge, considered self-supporting, is taken as

$$\frac{1}{2}\sqrt{\frac{112 \times t^2}{B}} \qquad \frac{dr}{2}$$

In these formulas

t = Thickness of the head in sixteenths of an inch;
B = Working pressure;
dr = Diameter of the tube hole.

CYLINDRICAL SHELLS

For calculating the pressure allowable on cylindrical shells the formulas, while in slightly different form, both give the same result.

For dished heads, concave to pressure, the Canadian rules state that when they are true portions of spheres and dished to a radius equal to or less than the diameter of the shell, they do not require staying if the thickness is $\frac{1}{16}$ in. more than the shell, but when dished to a radius greater than the diameter, the working pressure allowable may be calculated by the formula

$$B = \frac{(t - 1) \times T.S.}{R \times 56}$$

where

B = Working pressure;
t = Thickness of plate in sixteenths of an inch;
$T.S.$ = Tensile strength of plate;
R = Radius to which the head is bumped.

In the Massachusetts rules the working pressure on a head concave to pressure is given by the formula

$$P = \frac{t \times T.S.}{F.S. \times R}$$

where

P = Working pressure;
$T.S.$ = Tensile strength;
$F.S.$ = Factor of safety = 5;
R = One-half the radius to which the head is dished;
t = Thickness of plate in inches.

The Massachusetts rules allow a greater pressure for the same head. For example, a head 48 in. diameter, $\frac{7}{16}$ in. thick, dished to a radius of 48 in. and having a tensile strength of 60,000 lb. per sq.in., would be allowed 218 lb. working pressure in Massachusetts. By the Canadian rules such a head would not be used with a shell over $\frac{3}{8}$ in. in thickness. A shell of this thickness which, when fitted with the most efficient joint allowed, and with the lowest factor of safety, would not give over 180 lb. working pressure.

For heads convex to pressure, both rules allow only 60 per cent. of the pressure allowed on heads concave to pressure.

For externally fired boilers, the Canadian rules limit the diameter to 72 in., and all horizontal return-tubular boilers 48 in. in diameter and over must have a manhole in the front head below the tubes. Massachusetts does not limit the size of such boilers and a manhole in the front head below the tubes is not required in boilers under 60 in. in diameter. The Canadian rules also take up the construction of manholes, handholes and yokes with reference to material and design in much greater detail. They also give formulas for calculating the working pressure on the Adamson and corrugated types of furnaces, Truncated cones and many other special details not covered in the Massachusetts rules.

The specifications for material are practically the same in both cases, although shells may be made of flange steel in Canada while Massachusetts requires the firebox.

There are many other minor details which could be mentioned, but those given cover the most important. Doubtless, opinions will vary widely as to the merits of the respective rules, but in any case both have proved that they tend toward the production of high-class boilers.

⁂

Highest and Largest Chimney—A chimney 506 ft. high, the tallest in the world, has been built for the Boston and Montana smelters at Great Falls, Mont. Its nearest rival is 40 ft. shorter and the next highest in America is 140 ft. shorter. The main barrel of the chimney has an inside diameter of 50 ft. at the top and about 65 ft. at the base; its discharge capacity is 4,000,000 cu.ft. of gas per minute. There are 17,000 tons of brickwork in the entire structure, and the foundation, which is 103 ft. across at the bottom and 22 ft. 6 in. high, contains 4300 cu.yd. of concrete. An octagonal base, 78 ft. 6 in. across the bottom and 46 ft. high, separates the main barrel from the foundation. A dust chamber, 478 ft. long, 176 ft. wide, and 21 ft. high, closely hung with small wires, strains the smoke before it enters the chimney. The flue which leads from the dust chamber to the chimney is 40 ft. wide and 1238 ft. long. The whole chimney has an acid-proof lining.—"Popular Mechanics."

⁂

Travels of a Flywheel—A recent issue of "Popular Mechanics" mentioned an engine that has been running in New York City for about fourteen years, and that a mark on its flywheel during that time would have traveled a distance equal to nearly 200 times around the earth.

The Corliss engine built by the Crane Co., in 1880, and which ran one of the company's Chicago plants continuously for 30 years, had a record of travel that compares favorably with that of the New York engine, taking into consideration size of flywheel, revolutions per minute, running hours and actual working days. The New York engine has a smaller flywheel, but it runs 22 hours a day, 365 days a year, and makes three times as many revolutions a minute. The Crane Co.'s stanch old Corliss ran for 30 years, 10 hours of every working day, and during that time had a fly sat on one spot of the flywheel rim it would have traveled 2,500,000 miles, or about 100 times around the world.

⁂

The Foundation of Education—"Technical school is not the education of an engineer—it is merely the foundation upon which the complete structure of education is built by work, experience and further study." So Charles T. Main, '76, expressed his ideas of the engineer and his training before the banquet of the Mechanical Engineering Society at Boston recently.—"The Tech."

Baffling Water-Tube Boilers*

By Osborn Monnett†

SYNOPSIS—Different types of baffle for different boilers and the best length of gas pass to use in each case.

⁂

The ratio of heating to grate surface may be higher than in return-tubular boilers, especially where mechanical stokers are used. Ratios from 40 to 60 to 1 are allowable. At the higher ratios, however, it must be remembered that the furnace will be loaded to its maximum capacity before the capacity of the boiler to absorb heat is reached, so that the chances of making smoke on high capacities are increased. All things considered, a general average of 50 to 1 is a good ratio in the ordinary water-tube boiler plant using Middle Western bituminous coals. This ratio provides for a good overload capacity on the boiler without actually taxing the furnace to attain it.

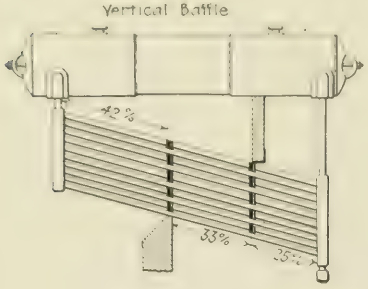


FIG. 1

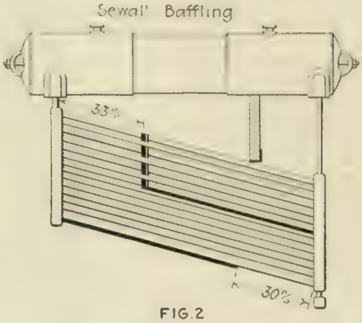


FIG. 2

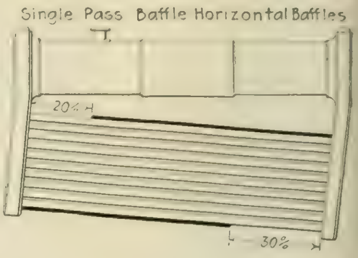


FIG. 3

Approximate Mean Length of 1st Bank of "Stirling" Tubes

CLASS	LENGTH
A	14'-2"
B	11'-6"
B (Low)	10'-4"
E	12'-8"
F	15'-9"
G	16'-9"
I	15'-3"
I-S	14'-9"
K	17'-5"
L	17'-6"
M	20'-2"
N	20'-0"
O	19'-10"
P	13'-6"
Q	16'-0"
R	17'-0"
S	15'-7"

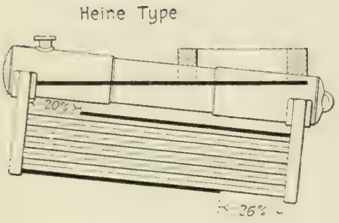


FIG. 4

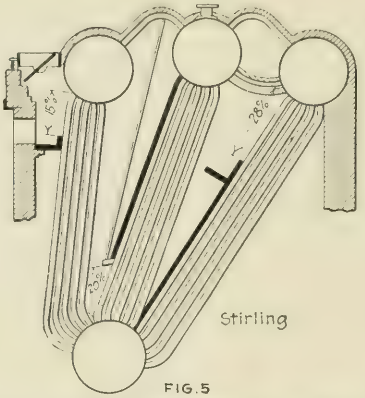


FIG. 5

POWER

FIG. 1. SPACING OF VERTICAL BAFFLES ON HORIZONTAL WATER-TUBE BOILERS. FIG. 2. B. & W. SEWALL BAFFLING. FIG. 3. SINGLE-PASS HORIZONTAL BAFFLES. FIG. 4. HEINE TYPE BAFFLING. FIG. 5. STIRLING BAFFLES

BAFFLING

A careful study of the areas through water-tube boilers using different types of baffle has revealed some interesting points. In the following discussion it should be remembered that types rather than actual makes are considered. There are two ways in which the openings in the baffling may be expressed; one in percentage of tube length and the other in percentage of connected grate surface. As the grate surface will vary according to the ideas of different designers, it is better to classify the gas passes in percentage of tube length. This is standard in different makes of boiler and is a fixed dimension which cannot well be changed by the engineer in laying out the plant.

Vertical Baffling—With any water-tube boiler that can be baffled, as in Fig. 1, the following percentages expressing the relation between length of gas pass and tubes have given good results: First pass, 42 per cent.; second, 33 per cent.; third, 25 per cent.

B. & W. Sewall Baffling—The average proportions, worked out from many successful installations, are given in Fig. 2. With a superheater, the second gas pass should be increased to 37 per cent. of the tube length. It is not advisable, however, to use this baffle on boilers less than 12 tubes high.

Single-Pass Horizontal Baffling—Fig. 3 shows a good arrangement for water-tube boilers, such as the Atlas, Aultman-Taylor, Babcock & Wilcox, Bass horizontal, Erie City, Cahall horizontal, Edge Moor, Flanners, Free-

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†Smoke inspector, city of Chicago.

man, Oil City (Geary), Kingsford, Keeler, Wickes horizontal, etc. As indicated, the first pass is 30 per cent. and the second 20 per cent. of the tube length.

Heine Baffles—Under this heading are included all boilers having tube spacing similar to the Heine and other boilers not suitable for vertical baffles, such as the Casey-Hedges, Kroeschell, Franklin, Goss, Parker, etc. The gas passes for this type of baffle have given best results when proportioned, as shown in Fig. 4.

Stirling Boiler—From the standpoint of smoke suppression, the openings in the Stirling baffles, as ordinarily installed, are small and cause loss of draft through the setting. This tends to prevent smokeless operation at high capacities. The ordinary furnace, either stoker- or hand-fired, designed for smokeless operation, requires more brickwork than the standard types and naturally there is a tendency toward restriction of the gas passes. Carrying this too far has a detrimental effect on the brickwork and results in an unsatisfactory installation. The baffle openings recommended for this type of boiler, as shown in Fig. 5, are: First pass, 28 per cent. of the mean length of the first bank of tubes; second pass, 20 per cent., and third pass, 15 per cent.

Many experiments have been made with the baffling in water-tube boilers to increase efficiency, and it has been found that, up to a certain point, restricting the gas passes has resulted in higher efficiency. This is probably due to the higher velocity of the gases and to the consequent increased heat absorption. Restriction of the gas passes, however, can be carried to excess in natural-draft installations, as the draft available is generally too low to overcome much additional resistance. The gas-pass dimensions given herewith represent commercial proportions that have been found satisfactory from the standpoint of smokeless operation, steaming capacity and efficiency.

Stopping Leaks in the Absorption Plant

By William S. Luckenbach

SYNOPSIS—What to use to test water for ice making to determine the presence of objectionable impurities. Where to look for leaks and how to stop them. How to clean the perforated weak-liquor pipe in the absorber without shutting down the system.

Simple Tests for Purity of Water

The water from which ice is made should be occasionally tested for its purity. If lime is present, carbonate of soda produces a white cloud; should the water contain iron, yellow prussiate of potash will turn water blue; if copper is present, the same chemical will turn water brown. Acetate of lead added to water containing sulphur impurities will cause it to turn black. For testing the presence of ammonia in water, there is nothing better than a few drops of Nessler solution* in a glass of the water or brine.

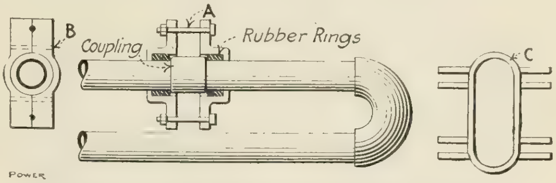
Leaks in the Exchanger

Suppose the hydrometer test shows the density of the rich liquor in an absorption machine to be 26 deg. Baumé, and the poor liquor 18 deg., equaling a distillation of 14 per cent. Now assume that the next test would show the weak liquor, say, 20 deg., or a distillation of only about 12 per cent., what is the cause and what is the remedy? There is only one cause, viz., not enough heat to liberate the gas, due to the generator coils or tubes not being clean or the steam of a lower temperature. This must be rectified at once in order to maintain capacity by either cleaning the coils or by increasing the steam temperature, or by using a larger volume at the same temperature.

Again, suppose the rich liquor decreased to 24 deg. and the poor liquor increased to 20.5; it is plain that there has been an exchange of ammonia, and as this can only occur in the exchanger, it must be cut out immediately by running a bypass temporarily and replacing the old coils or tubes with new as soon as possible. If this very important part of the system is thoroughly examined under a pressure of 500 lb. during the slack season, this trouble will be avoided, as well as the loss of several tons of ice when it is badly needed.

Leaks in the Absorber

When making the usual daily test of the water for ammonia leaks, should ammonia be found in the water flowing from the absorber, apply the same method to locate the coil or tube as described for the generator in a former article.† Should the perforations in the weak-liquor pipe extending into the absorber become partially closed, thus decreasing the supply necessary to absorb the return gas, the first move is to close the weak-liquor valve and get a vacuum on the absorber by keeping the ammonia pump running; then, by suddenly opening wide the poor-liquor valve, the excessive pressure may force the substance out and open the holes. Should this fail, be prepared to act quickly by again getting a vacuum, then disconnect the perforated pipe, pull it out, close the opening and clean and replace the pipe as soon as possible.



Stopping Ammonia Leak at Coupling

An automatic-regulating valve, to control the flow of the poor liquor, should be installed in every absorption plant. It is guaranteed to control the poor liquor just the same as a governor controls the varying steam pressure or load on an engine. Hence, when once properly adjusted, it will give the engineer ample time to carefully go over the plant and note the improvements he can make that will quickly return the investment for the improvement. The reason for advocating this adjunct is that the ordinary poor-liquor valve needs fairly close attention, as any change in the pressure of either the generator or the absorber will, of course, affect the flow of the liquor.

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*See "Power," Mar. 31, p. 450.

†"Power," May 5, p. 634.

LEAKS IN ATMOSPHERIC CONDENSING OR COOLING COILS

If, in testing the cooling water, ammonia should be present, it is important to stop the leak at once. It can usually be traced by white spots on the pipe or at threaded couplings and return bends, for in a few days the leakage will show a white incrustation. An ordinary band clamp bent to conform to the pipe and sheet of rubber will remedy the trouble, but in case the leak is in the threads of a coupling or return bend a split collar recessed for two quarter-inch rubber rings and then bolted together, as shown in cross-section at A, will effectually stop the leak without putting any strain on the threads or pipe.

The same split collar can be used on the return bends by making a pattern to suit the return bend, as shown at *C*. This collar is made of cast iron, with no machine work except drilling the two bolt holes shown in dotted lines at *B*.

The pattern has a thin core print nearly cutting the collar in two, and in order to split it after the bolt holes are drilled, simply drive a wedge or chisel in the cored slot. These collars are useful for other emergency repairs, and it is well to have at least two each of the various sizes on hand as ammonia leaks are far more expensive than a few cast-iron collars.

* * *

Coal Efficiency

By HAYLETT O'NEILL

SYNOPSIS—Showing the influence of the ash, moisture and hydrogen content of a coal upon its value as a steam producer.

* * *

Many large consumers of coal buy their fuel on the B.t.u. basis. In some instances, to form a correct estimate of the efficiency of coal as a steam producer, the ordinary method of estimating the value directly from the heat measurements made with a calorimeter should be modified.

INFLUENCE OF ASH

There is little doubt that furnace efficiency is greater with low-ash than with high-ash fuel. This is partly explained in that the combustible loss in the refuse dropping to the ashpit is proportionately greater with the higher percentages of ash in the coal. In every furnace the ideal is to burn out all of the combustible, but with coal in the usual form this is never attained in commercial practice. When most of the combustible is consumed, the remainder is so inclosed or so intimately combined with the slag that it is difficult for the air to unite with it for combustion. Therefore, complete burning would necessitate keeping dead fuel on the grates for an abnormally long time. Grates so occupied would produce little or no steam, while the air drawn through the fuel bed would do little but cool off the furnace, thus reducing the steaming capacity and the efficiency. Consequently, the fires must be cleaned in such manner that even under the most careful operation some combustible will be rejected to the ashpit.

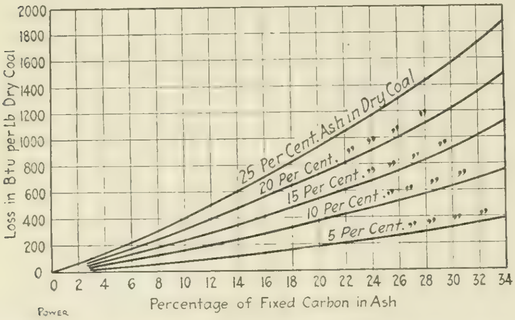


FIG. 1. LOSS DUE TO COMBUSTIBLE FALLING THROUGH GRATE

In general, the completeness with which the combustible may be burned economically depends upon the design of the furnace and the grate as well as the nature of the coal. Records of ash analyses for well operated plants and covering long periods of time generally show that the standard of proper carbon content in the ash discharged from a certain type of furnace and grate is well defined. Accordingly, the greater the percentage of ash, the greater the amount of combustible rejected to the ashpit.

Fig. 1 shows the losses due to combustible discharged to the ashpit. For every pound of dry coal fired, the fraction of a pound of carbon lost to the ashpit equals

$$\frac{A}{100 - C} \times \frac{A}{100} = \frac{C \times A}{100\,(100 - C)}$$

where

A = Percentage of ash in the dry coal;
C = Percentage of carbon in the ashes

The number of B.t.u. lost per pound of dry coal equals

$$14{,}600 \times \frac{C \times A}{100\,(100 - C)}$$

For example, assume 20 per cent. as the standard for carbon in the ash. With a coal containing 6 per cent. of ash and having a heat value of 14,600 B.t.u. per lb., the heat lost per pound of dry coal fired equals

$$\frac{14{,}600 \times 20 \times 6}{100\,(100 - 20)} = 219\ \textit{B.t.u.}$$

and the percentage loss equals

$$\frac{219 \times 100}{14{,}600} = 1.5\ \textit{per cent.}$$

With 12 per cent. ash, the loss equals 438 B.t.u. and the percentage is 3.

Besides fixed carbon, the refuse usually contains a small amount of volatile matter which can be neglected in ordinary calculations. The loss due to sensible heat in the red-hot ashes is almost negligible, being less than 0.5 per cent. with coals of less than 15 per cent. ash.

MOISTURE IN THE COAL

Water in coal must be evaporated and superheated to the flue temperature at atmospheric pressure. Thus, heat must be rejected to the chimney, and hence moisture in coal, in addition to being a dead weight, is an active heat waster.

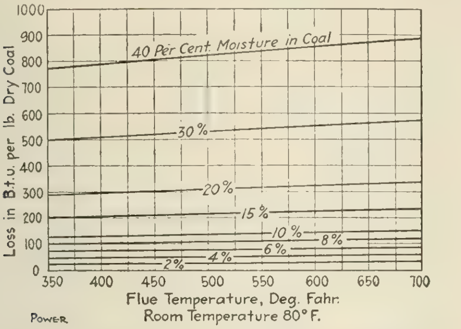


FIG. 2. LOSS DUE TO MOISTURE IN COAL

The B.t.u. lost per pound of dry coal equals

$$\frac{M \times (H - t + 32)}{100 - M}$$

where

M = Percentage of moisture in the coal as fired multiplied by 100 and divided by the difference between 100 and the percentage of moisture;

H = Total heat in 1 lb. of steam at atmospheric pressure and the temperature of the flue gases;

t = Room temperature.

For illustration, assume a coal of 14,000 B.t.u. (dry basis), 4 per cent. moisture, 80 deg. room temperature and 500 deg. stack temperature. The heat loss would be

$$\frac{4.2\ (1285 - 80 + 32)}{100 - 4.2} = 54\ B.t.u.$$

Fig. 2 shows the loss due to moisture. The percentage of loss is usually insignificant, being for the case given

$$\frac{54 \times 100}{14,000} = 38.5\ per\ cent.$$

INFLUENCE OF HYDROGEN IN COAL

A pound of hydrogen burned in an inclosed calorimeter will produce 62,000 B.t.u. Therefore, other things being equal, the richer the coal is in hydrogen, the higher its heat value. In a bomb calorimeter, the water which results from the burning of the hydrogen with oxygen is condensed and its latent heat thus given up is credited to the coal; but in an open furnace, this heat, together with that required for superheating from the temperature due to atmospheric pressure to the flue temperature, is wasted. Therefore, to estimate the true available heat of the coal, a deduction, depending upon the percentage of hydrogen, should be made from the calorimeter value.

When a pound of hydrogen burns, 9 lb. of water is formed. Therefore, when a pound of hydrogen burns, the heat necessary to evaporate superheat, 9 lb. of water is lost to the stack. This loss in B.t.u. per pound of dry coal equals

$$\frac{9 \times Hy \times (H - t + 32)}{100}$$

where Hy = Percentage of hydrogen in the dry coal;
H *and* t = Same as before.

For illustration, assume a coal of 14,000 B.t.u., containing 5 per cent. hydrogen, a room temperature of 80 deg. and a stack temperature of 500 deg. The loss per pound of dry coal equals

$$\frac{9 \times 5 \times (1285 - 48)}{100} = 557\ B.t.u.$$

and the percentage of loss equals

$$\frac{557 \times 100}{14,000} = 4\ per\ cent.$$

It will appear from the foregoing that a comparison on a straight B.t.u. basis of calorimeter values between an anthracite containing 2 per cent. of hydrogen and a bituminous coal containing 5 per cent. of hydrogen is erroneous.

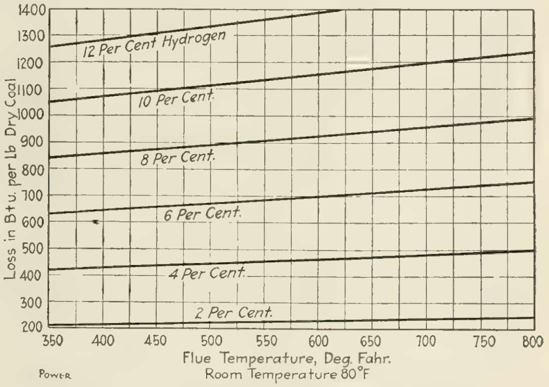


FIG. 3. LOSS DUE TO HYDROGEN IN COAL

Fig. 3 shows the loss due to hydrogen in different percentages. It is, moreover, entirely possible for several coals to show the same value in the calorimeter and yet differ as much as 3 or 4 per cent. in actual commercial value as steam producers.

⁂

A General-Utility Machine, says "Popular Mechanics" for office buildings, apartment houses, and small shops is now on the market, which is so adapted that its uses are manifold. Seventy-seven tools, so the manufacturers say, may be operated by this one handy contrivance. A friction-drive handle with flexible shaft attached to ¼- or ½-hp. motor, gives a speed of from 1650 to 2700 r.p.m.

⁂

Chalk Briquettes as Fuel in England—The Leeds briquette works at Hunslet has recently been making experiments to determine the possibility of the use of chalk briquettes for fuel. It is said that the company is able to obtain its chalk in the south of England at a cost of from 14 to 25c. per ton, and that it is proposed to sell it in briquette form at from $3.75 to $5 per ton. The briquettes are 5 in. long, 4 in. wide and 2½ in. thick. It is claimed that they burn with little or no smudge, with an exceedingly small amount of ash, and that they give off from 40 to 50 per cent. less smoke than coal. If the idea should prove as successful as seems posible from the foregoing it will be a large step toward the solution of the smoke problem.

Useful Boiler Tables

ALLOWABLE LOADS ON STANDARD WROUGHT IRON BOLTS FITTED WITH NUTS, FOR VARIOUS SAFE STRESSES PER SQUARE INCH

Diameter Top	Diameter at Root	Threads per In.	Area at Root	5,000	6,000	6,500	7,000	7,500	8,000	9,000
½	0.38	13	0.12	580	696	754	810	870	928	1,044
9/16	0.44	12	0.15	750	900	975	1,050	1,125	1,200	1,350
⅝	0.49	11	0.19	930	1,122	1,215	1,310	1,403	1,496	1,683
¾	0.60	10	0.28	1,410	1,698	1,840	1,980	2,123	2,264	2,547
⅞	0.71	9	0.39	1,970	2,364	2,560	2,760	2,955	3,152	3,546
1	0.84	8	0.52	2,600	3,108	3,367	3,630	3,885	4,144	4,662
1⅛	0.94	7	0.65	3,250	3,906	4,232	4,560	4,883	5,208	5,859
1¼	1.04	7	0.84	4,200	5,046	5,467	5,900	6,308	6,728	7,569
1⅜	1.12	6	1.00	5,000	6,000	6,500	7,000	7,500	8,000	9,000
1½	1.25	6	1.23	6,140	7,368	7,982	8,600	9,210	9,824	11,052
1⅝	1.35	5½	1.44	7,180	8,616	9,334	10,000	10,770	11,488	12,924
1¾	1.45	5	1.65	8,250	9,906	10,731	11,560	12,383	13,208	14,859
1⅞	1.57	5	1.95	9,800	11,700	12,675	13,640	14,625	15,600	17,550
2	1.66	4½	2.18	10,900	13,080	14,170	15,260	16,350	17,440	19,620
2¼	1.92	4½	2.88	14,400	17,280	18,720	20,180	21,600	23,040	25,920
2½	2.12	4	3.55	17,730	21,300	23,075	24,830	26,625	28,400	31,950
2¾	2.37	4	4.43	22,150	26,580	28,885	31,000	33,225	35,504	39,942
3	2.57	3½	5.20	26,000	31,200	33,800	36,360	39,000	41,600	46,800

Use 8000 lb. for Massachusetts under 1¼-In.   Use 6000 Lb. for Bolts on Removable Heads

ALLOWABLE LOADS ON STAYBOLTS, 12 THREADS PER INCH, FOR VARIOUS SAFE STRESSES PER SQUARE INCH

Diameter Top	Diameter Root	Area at Root	6000	6500	7000	7500
¾	0.6057	0.288	1729	1872	2016	2160
13/16	0.6682	0.351	2016	2282	2457	2632
⅞	0.7307	0.419	2514	2724	2933	3142
15/16	0.7932	0.494	2964	3211	3458	3705
1	0.8557	0.575	3454	3738	4025	4313
1 1/16	0.9182	0.662	3972	4303	4635	4965
1⅛	0.9807	0.755	4530	4908	5285	5663
1 3/16	1.0432	0.855	5130	5558	5985	6413
1¼	1.1057	0.960	5760	6240	6720	7200

Diameter Top	Diameter Root	Area at Root	6,000	6,500	7,000	7,500
1 5/16	1.1682	1.072	6,432	6,968	7,504	8,040
1⅜	1.2307	1.190	7,140	7,735	8,330	8,925
1 7/16	1.2932	1.313	7,878	8,535	9,191	9,848
1½	1.3557	1.444	8,664	9,386	10,108	10,830
1 9/16	1.4182	1.579	9,474	10,263	11,053	11,843
1⅝	1.4807	1.721	10,326	11,186	12,047	12,908
1 11/16	1.5432	1.870	11,220	12,155	13,090	14,025
1¾	1.6057	2.024	12,144	13,156	14,168	15,180
1 13/16	1.6682	2.185	13,110	14,203	15,295	16,388

Use 6000 lb. U.S.G. Indiana and Chicago.   Use 7000 lb. Massachusetts and Ohio 1¼ in. and over.   Use 6500 lb. Massachusetts and Ohio under 1¼ in.
Use 7500 lb. for Philadelphia, Pa.

ALLOWABLE PRESSURES PER SQUARE INCH FOR STAYBOLTED FLAT PLATES OF VARYING PITCH AND THICKNESS

Thick In.	Maximum Pitch in Inches 4	4⅛	4¼	4⅜	4½	4⅝	4¾	4⅞	5	5⅛	5¼	5⅜	5½	5⅝	5¾	5⅞	6	6⅛	6¼	6⅜	6½	6⅝	6¾	6⅞	7	7⅛	7¼	7⅜	7½	7⅝	7¾	7⅞	8
¼	165	149	136	125	115	107	99	93	86	81	76	72	68	64	61	57	55	52	49	47	45	43	41	40	38	36	35	34	32	31	30	29	28
5/16	237	215	197	180	166	154	143	133	125	117	110	103	98	92	87	83	79	75	71	68	65	62	60	57	55	53	51	49	47	45	43	42	40
⅜					227	210	195	182	170	160	150	141	133	126	119	113	107	102	97	93	89	85	81	78	75	72	69	66	64	62	59	57	55
7/16									222	208	195	184	174	164	156	148	140	134	127	121	116	111	106	102	98	94	90	87	84	81	78	75	72
½													220	206	197	187	178	169	161	154	147	141	135	129	124	119	114	110	106	102	98	95	92
9/16																	220	209	199	190	182	174	166	159	153	147	141	136	131	126	122	117	113
⅝																					220	210	201	193	185	178	171	164	158	153	147	142	137

Table calculated from Massachusetts formula, $P = \frac{66\,(t+1)^2}{S^2 - 6}$, in which P = lb. per sq.in. S = max. pitch, t = thickness in 16ths, 66 = constant.

EFFICIENCIES OF DOUBLE RIVETED LAP JOINTS

Tensile Strength = 55,000 Lb. per Sq.In. Shearing Strength of Rivets = 42,000 Lb. per Sq.In.

Pitch, In.	Hole, In.	Thickness of Plate ½	7/16	⅜	5/16	¼
2	1	50.0	50.0	50.0	50.0	50.0
	15/16	53.1	53.1	53.1	53.1	53.1
	⅞	56.2	56.2	56.2	56.2	56.2
	13/16	59.3	59.3	59.3	59.3	59.3
	¾	62.5	62.5	62.5	62.5	62.5
	11/16	56.7	64.7	65.6	65.6	65.6
2⅛	1	53.0	53.0	53.0	53.0	53.0
	15/16	55.9	55.9	55.9	55.9	55.9
	⅞	58.8	58.8	58.8	58.8	58.8
	13/16	61.8	61.8	61.8	61.8	61.8
	¾	63.5	64.7	64.7	64.7	64.7
	11/16	53.4	61.0	67.6	67.6	67.6
2¼	1	55.6	56.6	55.6	55.6	55.6
	15/16	58.3	58.3	58.3	58.3	58.3
	⅞	61.2	61.2	61.2	61.2	61.2
	13/16	64.9	64.9	64.9	64.9	64.9
	¾	60.0	66.6	66.6	66.6	66.6
	11/16	50.4	57.6	67.2	69.4	69.4
2⅜	1	57.8	57.8	57.8	57.8	57.8
	15/16	60.6	60.6	60.6	60.6	60.6
	⅞	63.2	63.2	63.2	63.2	63.2
	13/16	65.7	65.7	65.7	65.7	65.7
	¾	56.8	65.0	68.4	68.4	68.4
	11/16	47.8	54.6	62.6	71.1	71.1

Pitch, In.	Hole, In.	Thickness of Plate ½	7/16	⅜	5/16	¼
2½	1	60.0	60.0	60.0	60.0	60.0
	15/16	62.5	62.5	62.5	62.5	62.5
	⅞	65.0	65.0	65.0	65.0	65.0
	13/16	63.5	67.5	67.5	67.5	67.5
	¾	54.0	61.7	70.0	70.0	70.0
	11/16	45.3	51.9	60.5	72.5	72.5
2⅝	1	61.9	61.9	61.9	61.9	61.9
	15/16	64.3	64.3	64.3	64.3	64.3
	⅞	66.7	66.7	66.7	66.7	66.7
	13/16	60.4	69.1	69.1	69.1	69.1
	¾	51.4	58.7	68.8	71.5	71.5
	11/16	43.2	49.3	57.6	69.2	73.9
2¾	1	63.7	63.7	63.7	63.7	63.7
	15/16	65.8	65.8	65.8	65.8	65.8
	⅞	66.8	68.2	68.2	68.2	68.2
	13/16	57.6	66.0	70.5	70.5	70.5
	¾	49.1	56.1	65.4	72.7	72.7
	11/16	41.2	47.2	55.0	66.1	75.0
2⅞	1	65.2	65.2	65.2	65.2	65.2
	15/16	67.4	67.4	67.4	67.4	67.4
	⅞	63.9	69.5	69.5	69.5	69.5
	13/16	55.1	63.0	71.7	71.7	71.7
	¾	47.0	53.7	63.0	73.9	73.9
	11/16	39.4	45.1	52.6	63.1	76.1

Pitch, In.	Hole, In.	Thickness of Plate ¾	11/16	⅝	9/16	½	7/16	⅜	5/16	¼
3	1¼	58.3	56.3	56.3	56.3					
	1 3/16	60.4	60.4	60.4	60.4					
	1⅛	62.5	62.5	62.5	62.5					
	1 1/16	60.4	64.6	64.6	64.6	64.6				
	1	53.3	58.2	63.9	66.6	66.6	66.6	66.6	66.6	66.6
	15/16			56.4	68.8	68.8	68.8	68.8	68.8	68.8
	⅞				54.3	61.3	70.0	71.0	71.0	71.0
	13/16					52.8	60.4	70.4	72.9	72.9
	¾					45.0	51.4	60.0	72.0	75.0
	11/16					37.8	43.2	50.4	60.5	75.6
3¼	1¼	61.5	61.5	61.5	61.5					
	1 3/16	63.4	63.4	63.4	63.4					
	1⅛	62.2	65.4	65.4	65.4					
	1 1/16	55.5	60.6	66.7	67.3	67.3				
	1	49.2	53.7	59.1	65.6	69.2	69.2	69.2	69.2	69.2
	15/16			51.9	57.8	65.0	71.2	71.2	71.2	71.2
	⅞				50.3	56.6	64.7	73.1	73.1	73.1
	13/16					48.8	56.7	65.1	75.0	75.0
	¾					41.5	47.4	55.4	66.4	76.9
	11/16					34.9	39.9	46.5	55.8	69.8

Pitch, In.	Hole, In.	Thickness of Plate ¾	11/16	⅝	9/16	½	7/16	⅜	5/16	¼
3⅜	1¼	62.9	62.9	62.9	62.9					
	1 3/16	64.8	64.8	64.8	64.8					
	1⅛	60.0	65.6	66.4	66.4					
	1 1/16	53.6	58.5	64.2	68.4	68.4				
	1	47.4	51.8	56.9	63.2	70.3	70.3	70.3	70.3	70.3
	15/16			50.0	56.6	62.5	71.5	72.2	72.2	72.2
	⅞				48.4	54.5	62.3	72.7	74.1	74.1
	13/16					46.9	53.7	62.6	75.1	76.1
	¾					40.0	45.7	53.4	64.0	77.7
	11/16					33.6	38.4	44.8	53.7	67.2
3½	1¼	64.2	64.2	64.2	64.2					
	1 3/16	64.5	66.1	66.1	66.1					
	1⅛	57.8	63.2	67.9	67.9					
	1 1/16	51.7	56.4	61.9	68.8	69.6				
	1	45.8	49.9	54.8	60.9	68.6	71.5	71.5	71.5	71.5
	15/16			48.2	53.6	60.2	68.9	73.3	73.3	73.3
	⅞				46.7	52.5	60.0	70.0	75.0	75.0
	13/16					45.2	51.7	60.4	72.5	76.8
	¾					38.5	44.1	51.4	61.7	77.1
	11/16					32.4	37.0	43.2	51.8	64.8

Plate Failures

Rivet Failures

Courtesy of the Boiler Inspection Department of the Fidelity & Casualty Company of New York

Calculating Heat Losses from Buildings

By Charles L. Hubbard

The first step in the consideration of any system of warming, whatever its type, is to determine the heat loss from each room in B.t.u. per hour. This depends upon the character and extent of the exposed surface, the difference between the inside and outside temperatures, and the points of the compass.

The buildings considered in the present article may be included in four general classes, according to their construction and heat requirements. Class 1 includes office and municipal buildings, hotels, hospitals, theaters, schools, loft buildings, etc., where the walls are constructed of brick or stone with an inside furring of lath and plaster, and in which a normal temperature of 70 deg. is desired.

Class 2 includes shops and factories of brick or concrete, without furring, usually several stories in height, and also requiring a temperature of 70 deg.

Class 3 includes shops of modern design having walls of brick or concrete and thin roofs of different construction. Buildings of this type are usually heated to 60 deg.

Class 4 includes foundries, boiler and forge shops, etc., covered entirely, or in part, with corrugated iron, and heated to 50 deg.

These different classes of buildings will now be taken up in order, with tables and data for computing the heat loss from each within the usual range of conditions.

Class 1. For buildings in this class, the following data may be used:

TABLE 1. (WALL SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES

Solid Brick Wall with Lath and Plaster Furring and Air Space	Heat Loss in B.t.u.
8-in. brick	18
12-in. brick	16.5
16-in. brick	15
20-in. brick	12.5
24-in. brick	11
28-in. brick	10

For brick walls with sandstone face, 4 to 8 in. in thickness, plastered inside, but without furring or air space, multiply the factors in Table 1 by 1.3. For stone walls instead of brick, multiply the factors in the table by 1.3.

TABLE 2. (GLASS SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES

Character of Surface	Heat Loss in B.t.u.
Single sash	84
Double sash	42
Single skylight	91
Double skylight	46

For other temperature differences than 70 deg., multiply the factors in Tables 1 and 2 by the following: For 50 deg. multiply by 0.71; 60, 0.86; 70, 1; 80, 1.14; 90, 1.30.

In addition to the heat loss by transmission there is also a certain amount due to leakage, depending upon the tightness of the building construction, especially around doors and windows. This may be provided for in the average well built structure by multiplying the transmission loss by 1.2. For public rooms, where there is a good deal of passing in and out, it will be necessary to use a larger factor, depending upon local conditions. In main lobbies and similar rooms, a factor of 1.5 to 2 is often required.

Corrections for different points of the compass should be made as follows: For north exposure, multiply by 1.3; east, 1.1; south, 1; west, 1.2.

In rooms of considerable height, the heat loss is increased on account of the higher mean temperature and the more rapid circulation of the air over the cool surfaces. This amounts to about 2 per cent. for each additional foot above 12 ft. in height.

Although in office buildings the walls are reduced in thickness on the upper floors, it is not usually necessary to enlarge the radiators on this account, because the warm air, rising, is generally sufficient to offset any increase in heat transmission due to this cause. For very tall buildings, however, where the upper floors are more exposed to the wind, it may be necessary to allow for the thinning of the walls and also increase the factor for leakage.

When there is a low attic or roof space in which steam pipes are carried, no additional radiation is required to offset a cold ceiling on the upper story. In case of a roof space without steam pipes, increase the radiation about 15 per cent. When there is a solid roof, without air space, use the factor from Tables 4 or 6, which corresponds most nearly to the actual conditions.

Example: A room in an office building has a wall exposure of 450 sq.ft. and a glass exposure of 100 sq.ft. The walls consist of 8 in. of brick, with sandstone facing, plastered on the inside. The windows have single sashes, and the exposure is east. What will be the total heat loss per hour for a temperature difference of 70 deg.?

Factor for wall, 18 × 1.3 = 23.4
Factor for window = 84
Factor for leakage = 1.2
Factor for exposure = 1.1

from which the total heat loss is found to be

$$[(450 \times 23.4) + (100 \times 84)] \times 1.2 \times 1.1 = 24{,}987 \textit{ B.t.u.}$$

Class 2. Buildings of this type are usually of solid brick or of concrete, without insulating finish of any kind upon the inside walls, except in special rooms, such as offices, drafting rooms, etc.

TABLE 3. (WALL SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEG.

	Heat Loss in B.t.u.
Solid walls, 8-in. brick	31
12-in. brick	22
16-in. brick	18
20-in. brick	15
24-in. brick	14

For reinforced concrete, multiply the factors in Table 3 by 1.3. For ordinary wooden construction, with paper and clapboards on the outside and lath and plaster on the inside, use a factor of 21 for a temperature difference of 70 deg. For roof construction of different kinds, use Table 4.

TABLE 4. (ROOF SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEG.

Roof Construction	Heat Loss in B.t.u.
Slate on matched boards	21
Iron on matched boards	12
8-in. hollow tile, 1-in. concrete, tar and gravel	28
6-in. concrete, cinder fill, tar and gravel	38

For window surface, see Table 2.

With wooden sashes the factor for leakage may be taken as 1.3, while for iron sashes, which are much tighter, it may be reduced to 1.10.

In shops and factories where the floors are undivided by partitions, and the walls exposed to all four points of the compass, a factor of 1.16 may be used when correcting for exposure.

For other temperature differences than 70 deg., use the factors given under Class 1.

Class 3. The conditions here are much the same as in Class 2, except that the entire building is treated as a single room and a lower inside temperature is maintained.

TABLE 5. (WALL SURFACE) HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 60 DEG

	Heat Loss in B.t.u.
Solid walls, 4-in. brick	40
8-in. brick	26
12-in. brick	19
16-in. brick	16

For reinforced concrete, multiply the factors in Table 5 by 1.3.

TABLE 6. (ROOF SURFACE) HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 60 DEG

Roof Construction	Heat Loss in B.t.u.
Patent roof (tar and gravel)	18
6-in. hollow tile, 2-in. concrete, tar and gravel	22
4-in. concrete, cinder fill, tar and gravel	36
Unlined metal	78

For tile and concrete floors on earth, use a transmission factor of 6 for ordinary conditions.

For single windows, and a temperature difference of 60 deg., use a transmission factor of 72.

Leakage may be treated the same as in Class 2, using the factors 1.3 and 1.1 for wooden and iron sash, respectively.

The factor for exposure may be taken as 1.16, considering the whole building as a single room.

Class 4. Buildings of this type are confined chiefly to foundries, boiler shops, forge shops, etc., where the normal inside temperature may be comparatively low. Tests show that the transmission losses through unlined corrugated metal are nearly the same as for a single window, and for all practical purposes no distinction need be made between the walls, windows or roof in buildings of this kind.

Taking the transmission factor as 65 for a temperature difference of 50 deg., and multiplying by 1.3 and 1.16 for leakage and exposure, respectively, gives a total loss of

$$65 \times 1.3 \times 1.16 = 98.02 \text{ B.t.u.}$$

per square foot of gross area per hour. To this should be added a transmission of about 5 B.t.u. per square foot of floor area.

In general, a heat loss of 100 B.t.u. per square foot of gross wall and roof area will safely cover all ordinary conditions where the outside temperature does not drop much below zero.

❖ ❖

Odd Ammonia-Condenser Trouble

By A. G. Solomon

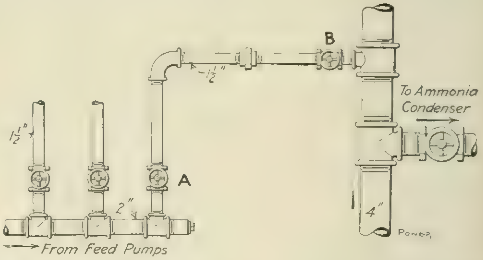
While overhauling an ice plant, it was found necessary to do some work on the boiler-feed pumps and heaters. While this was being done, the boilers were supplied with cold water direct from the pumps that were used to circulate water through the double-pipe ammonia condensers.

The pipe arrangement is shown in the illustration. The boiler-feed pumps discharged into a manifold from which a feed line extended to each boiler, and the feed valves were so placed as to be easily reached. To make a neat job the cold-water line was connected into the manifold and extended upward as did the feed lines to the boilers. The other end of this line was connected close to the pipe that supplied water to the ammonia condenser. A valve was placed at each end of this temporary feed line, that at the manifold being located in the same relative position as was the regular boiler-feed valves.

During the time this temporary line was in use, the ice machines were not needed, so the line answered the purpose, as the condenser pumps were designed for high-pressure service and they easily pumped into the boilers. When we were ready to use the regular feed pumps and heater again, we shut the valves *A* and *B*, and fed through the other feed lines.

One day the condenser pressure began to rise in jumps. One ice machine was immediately shut down, but still the pressure increased. The other machine was stopped, but the pressure remained much above where it should be; in fact, it kept slowly going still higher. To relieve the condenser, the expansion valves on the ice tanks were opened wide and the ammonia allowed to go into the coils.

What had caused the sudden raise of pressure puzzled all. On going outside to the condenser it was found that the coils were hot. Then the fireman located the trouble. He had opened the valve on the cold-water line at the manifold by mistake and we found that the valve on the other end of this line had become open a few turns by the jar set up by the pumps. After closing both valves tight we started one of the ice machines. During the time that the condenser pressure was high and the expansion valves were open, much liquid got into the coils in the ice tanks. It took over an hour of "pumping down," with the machine running slowly to get rid of the liquid and allow of starting the other machine. The cold-water feed line was disconnected at a union and the two ends left open.



Connection between Feed and Ammonia Condenser Mains

Editorials

The Power-Plant Arteries

Considering the amount of pipe work, especially for steam, that has been done since high pressures become common, one wonders at the large number of accidents still occurring yearly, due to defective work. Enough has been said in the engineering press, and discussion among engineers has been sufficiently widespread, to insure that all interested may obtain adequate and trustworthy information relative to the proper arrangement for piping for various conditions. With all the recorded information available, however, there is much piping so put up as to be dangerous. It is certain, therefore, that it is the human element which is at fault in this as in so many other channels of effort.

The most common defect is improper provision for draining the lines of condensate. It is fortunate that a poorly designed piping layout may be made safe usually if one will take the trouble to put in enough drain lines, place them where they belong, and provide reliable traps.

Just as a proper condition of arteries of the body is essential to the health and even the life of living beings, so, too, must the power-plant arteries be right for the sake of the safety of the equipment and those who care for it.

Make the piping right; it pays.

⁂

Burning Soft Coal without Smoke

During recent years there has been a great deal of agitation over the question of smoke in the larger cities of the country. Ordinances have been passed and enforced to a degree permitted by the slow working of the courts. Campaigns of education have been started and in most cases have done more good than the fines imposed, as those violating the ordinances were shown how to eradicate the evil and to use firing methods conducive to smokeless operation. Progress has necessarily been slow, as each installation formed an individual problem which had to be solved under the conditions existing.

To more successfully reduce the smoke nuisance, departures from standard furnaces were made. The results were carefully watched and improvements effected until new designs were evolved, which may appear radical to the conservative observer. For different kinds of fuel, varying rates of combustion and distinctive types of boiler, the modifications are many and have necessitated much original work and close observation by the personnel of the various smoke departments.

Chicago has been a leader in this new work. At one time it produced enormous quantities of heavy, black smoke, and more soot to the square foot than any other city in the country, with perhaps one or two exceptions. This was due to the improper burning of a fuel which, for the most part, was bituminous coal of a highly volatile character. Due to the large number of railroads and other causes, the conditions are not yet ideal, but they are greatly improved.

During the past seven years the Chicago Smoke Department has had a corps of mechanical engineering experts engaged in the practical work of smoke suppression and it has collected an enormous amount of data. Starting with the last issue, the results of this work are to be given in POWER in a long series of articles written by the chief smoke inspector. It will be his endeavor to present the material in a simple manner, showing good practice in furnace design and in methods of burning from the standpoint of actual experience in the field.

While the average consulting engineer may have details of a half-dozen boiler plants in his office in a year, the Chicago Department of Smoke Inspection in the same period passes on upward of five hundred distinct plants, aggregating from one thousand to one thousand two hundred separate boilers. These installations, when completed, operate under the eyes of the mechanical engineers in the department and valuable experience is thereby collected, showing what a steam plant will do in actual service.

The series starts with an analysis of the gas passes, grate surface, damper areas, breeching areas and stack height and section in relation to the best practice from the standpoint of smokeless operation. After these subjects have been covered, the actual designs of furnace will be taken up, commencing with hand-fired furnaces and horizontal return-tubular boilers. Hand-fired furnace development will be outlined with special reference to the burning of Illinois bituminous coals, and the reasons for the final adoption of the furnaces now in vogue will be considered. Hand-fired furnaces in connection with water-tube boilers for burning coal or mixed fuels, such as wood refuse and sawdust, will then be given attention.

Stokers for different types of boiler will be discussed and working drawings shown of actual settings known to be successful. The series will continue with the consideration of mechanical stokers alphabetically, commencing with the chain grate. The articles will deal with all kinds of boilers on the American market and show how the different types of stoker can be made to give satisfactory results. Most of the illustrations will be working drawings, indicating how each setting was installed, and the selection of the different types of setting will be from those most successful under the observation of the author. In this way a large number of smokeless settings will be shown, so that the series should be of great value to the consulting engineer, the operating engineer and the fireman.

A large part of the smoke inspector's work is to clean up existing settings installed under adverse conditions, such as low headroom, small floor space and the limits to excavation due to floating foundations and the inadvisability of going below the sewer level. A special series will be devoted to many installations made successful under these adverse conditions.

The man in the plant should know how to burn his fuel smokelessly, what type of hand fired furnace or stoker is best adapted to his work, how the boiler should be baffled, the proper draft for different rates of combustion, the best type of damper and where to locate it, and many other things which will enable him to operate his boilers to the best advantage and without smoke. When the fuel is bituminous coal or wood refuse, this series will give this information. The treatment is simple and direct and not over the head of the average fireman. The combined work of a progressive department covering a period of seven years should be worth a great deal. It will pay to follow the series closely and give every article the attention it deserves.

A Comparison of Boiler Standards

Both Canada and the United States are giving increasing attention to regulations governing the construction of steam boilers. The comparison of the standards put forward by the Canadian provinces and by Massachusetts, the latter as representing the best of our practice, beginning on page 698, of this issue, will be found especially interesting and instructive. Analytical study to determine the best of the existing laws as models for future legislation may be made with profit by such of the states as have yet to enact statutes for safer boiler operation.

Some important differences in the requirements imposed by the Canadian provinces and by Massachusetts deserve further comment. First, with regard to the approval of designs, more might be said concerning the Canadian practice of approving the design in advance of construction, instead of leaving the manufacturers to interpret the rules at their own risk. When a Canadian manufacturer has obtained the approval and registration of a design, he is reasonably sure that his completed boiler will pass inspection. It is merely incumbent upon him to follow faithfully his drawings and specifications covering both the design and the workmanship. On the other hand, the manufacturer building his first boiler of any given type for use in Massachusetts, must wait until its completion before he knows that it is acceptable. It can easily be seen that the Canadian procedure is likely to save loss of time and of money for the manufacturer.

Mr. Macdonald, the author of our comparison, makes the point that the five- or ten-dollar fee charged for approving and registering a design in Canada conduces to standardizing practice to fewer designs. We should hardly credit the size of the fee as enough to have much influence in this direction, but we do believe that the trouble and time and other expenses involved in securing a registration will have a tendency to avoid a multiplicity of designs. At the same time, the Massachusetts practice may have an even greater effect of the kind, for a boiler builder, having gone through the experiment of learning what form of design when finished will pass, is likely to depart as little from it as possible in his subsequent product and other manufacturers are likely to imitate his successful design.

In the methods of stamping and identifying we should regard the form required by Alberta, Canada, better than that of Massachusetts, in that it gives more particulars. Simplicity is desirable and the Massachusetts marking may cover the essentials, but one can readily conceive of instances, however few, that might justify the little added effort required to supply the extra information given on the Canadian stamp. For one thing, the recording of the grade and the make of the plate impresses the makers of both the boiler and the plate with the need of using proper material. The plate maker in particular feels his responsibility when the plate is identified as his.

We indorse that provision in Canada of a stamp "For Heating Purposes Only" on all heating boilers. Like the label "For External Use Only." on packages containing liniments or poisonous drugs, it makes it a clear case of attempted suicide to misapply the article marked.

As to the different ways of determining the factor of safety, the Canadian way may be more thorough, but it is also more complicated. A striving for such scientific exactness in the prescription for the factor of safety when so many variable factors are to enter later, such as unknown defects in material, individual workmen's differences in workmanship and individual inspectors' differences in judgment, would seem futile. It strikes us as about as justifiable as weighing the coal and water for a boiler test to fractions of an ounce when the condition of the fire and the level of the water in the boiler at the beginning and end of the test are judged by the eye. In working up the results of a test where countless errors can enter in, the final figures are apt to be as accurate when a slide rule is used as when the calculations are all carried out to the sixth decimal place.

The factor of safety, or "factor of ignorance," as it is sometimes called, is a guess anyhow, and we venture that a Yankee can guess according to the Massachusetts method with equal closeness.

Some advantages may attend the use of rules covering the design of riveted joints to the greater detail followed in Canada than in Massachusetts. It tends to uniformity in the practice of different manufacturers and, as Mr. Macdonald says, "discourages freak joints." We are not prepared to admit, however, that it is advisable not to allow the manufacturer enough latitude to enjoy the fruit of his experience by employing such joints as he has found best for given purposes. Manufacturers of limited competence will be protected against their own shortcomings by the Canadian rules, but who can say that the makers of rules are always better qualified than the builders of boilers to know what is right? If rules are drawn up, as they should be, in conference with the best talent in the boiler-making business, and the recommendations of the latter are embodied, they will be sufficiently comprehensive. The same applies whether they are for joints, stayed surfaces, cylindrical shells or for heads.

Our principal concern is not with the minutiæ of the rules and regulations governing boiler construction as now in force in certain of the provinces and states; they can work out their own salvation. What we earnestly ask is that more provinces and more states will adopt rules of some kind. Anything is better than nothing, and too many commonwealths have no boiler laws.

* * *

The "Useful Boiler Tables" on page 706 were compiled by and for the Boiler Inspection Department of the Fidelity & Casualty Company of New York to which we are indebted for the privilege of presenting them in our pages. While primarily for the convenience of boiler inspectors, they are obviously handy for any one having to do with boilers.

Correspondence

Getting Rope to Top of Stack

In the Feb. 10 issue a letter told how to get a rope over the top of a chimney. It reminds me of a similar job done on an 80-ft. steel stack preparatory to painting it. There was no pulley on top, and as it was in service it was impossible for the painter to get up through the inside.

The guy ropes which held the stack were fastened 12 ft. below the top. To get a rope to the top of the stack the following means were adopted. A steel cable with a shackle at one end was put completely around the outside of the guy ropes, forming a circle. The loose end was passed through the shackle as a rope passes through an eye. To the shackle a pulley block having a long rope attached to a bosn's chair was hooked. By pulling on the loose end of the shackle rope, that rope and the pulley were pulled up over the guy ropes until they reached the point 12 ft. from the top of the stack. Then the loose end was made fast to prevent the shackle rope from slipping down over the guys. The bosn's chair was then hoisted, the painter sitting in it and having a 15-ft. pole to which was hooked a roped pulley block having a hook which the painter slipped over the top of the stack with the aid of the pole. The bosn's chair was then made fast to the second rope and the painting of the stack begun.

W. A. Cooil.

Ladysmith, B. C., Can.

* * *

Boiler Settings

The horizontal return-tubular boiler is the most widely used in the United States, and the setting usually provided is about the same in general design in all sections of the country. There are two main faults generally to be found with the setting used for such boilers, the first being that they are almost always set too low. The cause of this error probably originated and was perpetuated owing to a misconception of the true principles involved in efficient furnace performance and because of the extra cost involved in setting such boilers high. After all that has been said about the theoretical and the practical requirements for economical furnace performance, there are few uptodate engineers who will contend that the added cost to the boiler setting, and possibly the boiler house, required to set boilers a sufficient distance above the grate to procure good combustion, is not warranted.

Another feature which is usually wrong with such boiler settings is that the walls are nearly always built with air spaces in them. Probably no water-tube boiler today has its setting arranged with air spaces left in the walls, because their settings are relatively high, and if the attempt were made to leave air spaces in such walls, when built of the usual thickness, they would probably fail in use.

No one has ever advanced a reasonable theory for the use of an air space in setting walls, but there are many good reasons why they should not be used. In the first place, as pointed out, they weaken the walls. Another thing, of much importance, is that the air space permits the leakage of outside air to the furnace and the combustion chamber. No engineer would think of covering a steam pipe with a sheet-metal tube larger than the pipe and passing air through the annular space between the two to prevent radiation losses. Yet this is practically what is done in the case of the horizontal return-tubular boiler setting.

The "pull" of the stack produces a lower air pressure on all the inner surfaces of the setting than that exerted on the outer surfaces. This causes a constant leakage of air through all cracks and crevices, and even through the pores of the brick, and an air space in the wall necessarily promotes such leakage.

Some builders have gone so far as to leave openings in the outer walls of the setting and at the top of the walls to provide ready means for the air to reach this space, which seems ridiculous.

High settings built with solid walls, properly protected by means of plastic asbestos cement or otherwise to prevent air leakage, will prove a good investment for any plant. With the ever increasing vigilance of the smoke inspector, the high setting with tight walls will be required of the boiler user and in a manner similar to others of the past, economical conditions will be forced on him by outsiders who have no interest in the economical operation of his plant.

J. E. Terman.

Hartford, Conn.

* * *

Care of Boilers

In his letter in the Mar. 31 issue, page 454, H. H. Burley states that two water-tube boilers under his care have been run 19 years without having the pressure reduced by the police or the insurance authorities. This is a good record. Mr. Burley also says that each boiler is used for one month and then cut out of service for cleaning; a pressure of 100 lb. is carried.

I believe my two water-tube boilers have a record that beats Mr. Burley's. They were built in 1882, are of 75 hp. each, and carry a pressure of 80 lb., which has never been reduced. We run six days a week, 51 weeks a year, one week being set aside for general overhauling. Unlike Mr. Burley, we use a compound, but do not employ a mechanical cleaner in the tubes. Condensate or "returns" is not used, it being allowed to go to the sewer.

The boilers were originally fitted with cast-iron mud drums, but as one burst, both boilers were then equipped with steam drums.

I have had considerable marine experience and have seen boilers on shipboard that were 25 to 28 years old.

A. England.

New York City.

While the Chief Was Away

In the case cited in the letter under this title, in the Mar. 31 issue, many improvements were made and much money was saved by changes in plant operation during the absence of the chief engineer.

Undoubtedly, there are underlying causes of which we have no information. If the chief was above listening to suggestions from his subordinates, then the matter is understandable, but if he was not, why did not someone of the force bring these things to his notice? It is unreasonable to suppose that no one at the plant was aware of existing conditions, and it would have been but common honesty and loyalty, both to the chief and the company, to have reported them.

The statement about the dampers and the indicator in the engine room, which was supposed to tell when the dampers were closed, is interesting. Fancy a man being obliged to crawl inside the flue to find out what the dampers were doing when draft gages are so cheap and plentiful. When boilers are equipped with draft gages there is no need of a home-made telltale in the engine room.

An engineer in a large plant has little time to look after boiler-room matters. The better way is to have a capable man in charge of that department.

From the information published, it would seem that things were not uptodate in this plant, although steps seem to have been taken in the right direction.

I wonder why the master mechanic did not coöperate with the chief to the same extent that he did with the assistant chief and use a little team work.

William Plaisted.

Redondo Beach, Calif.

I contend it is necessary for the efficient operation of any power plant that the chief engineer treat his men with some consideration instead as mere laborers. To be successful, the chief must have the coöperation of his men. He may be forced to discharge a few at first, but if he will consult with his men occasionally, he may get ideas that will make his position easier.

Take, for instance, the case cited by Mr. Olliver. Had the chief been the kind of man to confide in, he would have learned of the assistant's idea to reduce the coal consumption, and could have accomplished the saving that was made while he was away. A chief should get all of the information out of his men that he can, but he should not act on their suggestions without giving them credit for the idea; that would be unfair.

Some time ago I read a description of the plant in one of the largest packing houses in the country and was impressed with the manner in which the engineers were made—"made" is the proper word—and treated. The chief is in consultation every morning with his assistants and they consult with the men in their departments concerning the work. This is a large company, and the men are promoted to a higher position whenever there is a vacancy or a new plant is started.

The men are required to study, and are sent to the various plants that they may become familiar with the work in all of them, so that in an emergency case they can be sent to any plant instead of hiring new men. This encourages them, and gives them an incentive to do their best.

Some engineers hold that if a chief became familiar with his men he would have trouble to get them to obey a disagreeable order, and that there would be no discipline. If a man gets the idea that because he is treated with respect he does not have to obey orders, he should be discharged. The plan as worked out by the company mentioned signifies that it is successful from the viewpoint of both sides.

Every man in the plant should be entitled to equal consideration, no matter what his position. When any complaint arises where the actions of one man are questioned by another, have both sides of the controversy present, and give each side a chance to prove his case. This will check the practice of tale bearing and knocking, which is found in some plants.

J. C. Hawkins.

Hyattsville, Md.

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CO_2 Recorders for Standby Boilers

Generally, where boilers are operated below rating, heavy heat losses are likely to result. On the other hand, if boilers are crowded or operated considerably above rating during the "off peak" periods, the remaining peak boilers must be kept banked. This, as everyone knows, is most wasteful.

If CO_2 recorders are installed and the firemen are required to carry more than 8 or 10 per cent. CO_2 during the light-load periods, then a larger number of boilers can be operated at a greater net efficiency than is possible by crowding a few and using coal to hold the rest in reserve. This will cause the firemen to regulate the fires as to thickness, as well as regulating the checked draft, keeping in mind that when the damper is closed the door to the coal pile is shut. Without the recorder it is practically impossible to operate boilers under rating without having the fires full of holes. There is always some chance when operating with checked draft and thick fires of having much CO present, but if the CO_2 is reasonably high, one does not need to bother about the CO content.

John F. Hurst.

Louisville, Ky.

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Pass It On

In connection with your editorial on trade periodicals in the Mar. 24 issue, perhaps your readers would be interested in our system for "passing on" the articles appearing in the trade papers which would be of interest to our organization.

All publications received are carefully looked over by two members of the publicity department and the items of interest marked. These items are then clipped and mounted on a stiff card. After mounting they are finally passed upon by the writer, and such as do not appeal to him as being of interest are so marked and eliminated. The balance are tabulated on the "Week's News" sheet, as in the form herewith.

Copies of this sheet are distributed to everyone in the organization and are returned to the department with a check mark opposite the articles which are wanted. The card carrying the article wanted is checked to indicate to whom it is to go and sent from one to the other.

Finally it is returned to the department and placed on file.

The articles are filed under such general classes as Riveters, Air Compressors, Pneumatic Drills, Hoists, Foundries, Machine Shops, etc.

This system has been successful and saves a great deal of time for the busy man.

THE WEEK'S NEWS

To Mr. A. B. Smith **Date** Sept. 10, 1912

Check	**Title and Subject**	**Paper**	**Date**
	Slides in the Culebra Cut at Panama	Engineering Record	8/31/12
	Seepage in subaqueous railroad tunnels.......	Engineering Record	8/31/12
	Progress of the Lexington Ave. subway.......	Engineering Record	8/31/12
	Water..................................	Engineering Record	8/31/12
	Railroads................................	Engineering Record	8/31/12
	New pneumatic hammer at Panama.........	Industrial World	8/26/12
	Shaft sinking reversed.....................	Mng. & Scientific Press	8/17/12
	Metallurgy at Bendigo.....................	Mng. & Scientific Press	8/17/12
	Electric motors for mines..................	Coal Age	8/31/12
	The Colorado River siphon at Yuma, Ariz.....	Engineering News	8/29/12
	Coefficients of flow in Manchusett Aqueduct..	Engineering News	8/29/12
	Improvements in Pittsburgh's water supply system................................	Engineering News	8/29/12
	Methods of ventilating railroad tunnels......	Engineering News	8/29/12
	Construction and operation of turbo-blowers and compressors.........................	Engineering Magazine	Sept.
	A rope-driven coal cutter..................	Engineering Magazine	Sept.
	Power machinery of the steel industry.......	Engineering Magazine	Sept.
	Notes on sand blast.......................	American Machinist	8/29/12
	Drilling charts for iron and steel............	American Machinist	9/5/12
	An exhaust-gas turbine.....................	The Engineer	8/23/12
	The rotary drill in the oil fields............	Mng. & Eng. World	8/31/12
	Churn-drill examination of placers..........	Mines & Minerals	Sept.
	Goulds new triplex pumps..................	Practical Engineer	9/1/12
	New centrifugal pump......................	Practical Engineer	9/1/12
	Trouble in a pumping plant.................	Practical Engineer	9/1/12
	Setting up turbines........................	Practical Engineer	9/1/12
	Tests for packing..........................	Practical Engineer	9/1/12
	Missouri River power station...............	Power	9/3/12
	Water works of the Kansas Cities...........	Power	9/3/12
	Power plant of the Kansas City Star.........	Power	9/3/12
	A National Biscuit Co. plant...............	Power	9/3/12
	Inspecting and testing electrical apparatus....	Power	9/3/12
	Nordberg variable capacity power pump.....	Power	9/3/12
	Impulse and reaction turbines..............	Power	9/3/12
	Copper range drill jack and post............	Eng. & Mng. Journal	8/31/12
	Stope filing and caving for waste............	Eng. & Mng. Journal	8/31/12

The above are on file in the Publicity Dept. Information Bureau and can be had for a limited period on request.

If wanted, please designate by checking opposite article wanted and return to Publicity Dept.

Signed A. B. Smith.

CHARLES A. HIRSCHBERG,
Ingersoll-Rand Co.

New York City.

⁂

Alterations to Furnace Prevent Smoke

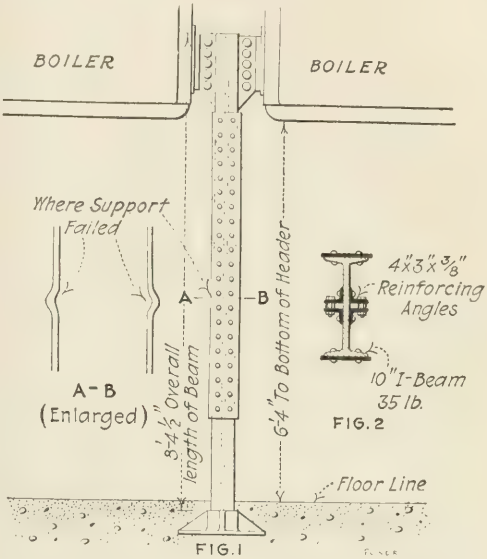
In our endeavor to eliminate smoke, we decided to reconstruct the furnaces under four water-tube boilers, which are arranged in batteries of two. These boilers are served by one stack, independent of the rest of the station, and offer a good chance for observation. The old furnaces are flush with and under the boilers, with front-feed, inclined-grate stokers and a combustion arch. One would think these furnaces should burn the volatile, but when we are required to force the fires, coking takes place further down the grate and much gas is distilled. Before complete combustion takes place the unburned gases have reached the comparatively cool boilers and a dense smoke is emitted from the stack.

After a careful study of conditions, it was decided to give the gases a longer course before they reached the boiler. We, therefore, built an extension to the furnace which brought the grate 3 ft. forward. An arrangement of the arch and other details of more or less importance have brought about the desired results.

While we have not as yet made tests to determine the efficiency of the new over the old furnaces, we have every reason to believe that while we have eliminated smoke we have also increased the furnace efficiency.

We have, however, effected one material saving, where in the old furnaces we lost considerable unburned coal from sifting through the grate and falling into the ash hopper. The new arrangement allows for an extra hopper to catch this fine coal, which amounts to at least a ton a day for each boiler. This saving alone will pay for the improvement.

It was while making these improvements that we discovered what we think a defect in the old furnaces. The front and side supports are so near the intense heat of the furnace that they failed at a point *AB* in the sketch. We repaired the supports by adding stiffening angles to the web of the I-beam, as shown in Fig. 2. This makes a substantial repair job, and with proper insulation and adequate air ducts it will be a lasting job.



HOW THE SUPPORT WAS REINFORCED

H. R. BLESSING.

Philadelphia, Penn.

⁂

Auxiliary Economy in Steam Power Plants

Mr. Carpenter, on page 437 of the Mar. 31 issue, uses arguments against electrically driven auxilaries which are inconsistent with the rest of his article. Electric auxiliaries and bleeding steam from the main units to heat the feed water will show the same saving that more economical steam auxiliaries do if the main unit, noncondensing, can drive them with less steam than steam-driven auxiliaries would take.

Electric auxiliaries would take about 1½ brake horsepower on the turbine shaft for each horsepower delivered to the auxiliary, which would include transmission and motor loss and that would make the water rate 33 lb. per horsepower-hour. A steam-driven auxiliary using 35 lb. of steam per horsepower gives nearly the same economy, and other features, such as price and control, would decide whether it was the most economical

Mr. Carpenter also says: "Even in this case, if steam at boiler pressure can be used in the heating systems, efficient utilization of steam in the pumps, etc., is desirable as it further minimizes the heat extracted for power." This is clearly a mistake. One horsepower-hour means 2545 B.t.u. extracted for power. If a pump or an engine uses 30 lb. per horsepower-hour, 2545 B.t.u. are taken from 30 lb. of steam. If the engine or the pump uses 60 lb. per horsepower-hour, then 2545 B.t.u. are taken from 60 lb. of steam, but, in any case, 2545 B.t.u. No more, no less.

Radiation from the steam cylinder takes a little more, but radiation on a well covered duplex pump would be as little as on a more economical machine. Efficient pumps and engines are desirable, as during a large part of the year there is exhaust to throw away, but when all the exhaust can be used for heating it makes no difference how much steam per horsepower-hour is used. I doubt if he means, "Also steam at boiler pressure."

HARRY D. EVERETT.

Fort Snelling, Minn.

⁂

A Pump-Suction Indicator

A vacuum gage is most useful in connection with pumping installations. Even the smallest plant should have a gage attached to the suction pipe near the pump. Theoretically, the reading multiplied by 13.5 and divided by 12 should give the suction lift in feet. On a new outfit the gage should be calibrated by noting the vertical distance above the water as compared to the calculation from the gage. If it shows a greater vacuum than it should, the difference is due to resistance in the suction pipe or strainer. I have seen a vacuum of 28 in. when the water was 26 ft. vertically from the pump.

Leaks in the suction will cause a variation. After once calibrating the gage to suit the conditions, any trouble, such as stoppage of strainers, etc., can be readily noted by an increased vacuum shown upon the gage.

JOHN F. HURST.

Louisville, Ky.

⁂

Direct-Current Fan Motors on Alternating Current

Around many of the older plants will be found a variety of discarded direct-current apparatus. Usually the collection contains a fan motor or two which might be put to good use when the warm weather comes. Any small, direct-current motor may be changed to run on alternating current with a fair degree of efficiency providing its field circuit is of laminated construction.

A direct-current, shunt-wound motor will run when connected to an alternating-current circuit, but it will heat badly and the current will be excessive, due to the phase displacement of the field current by the high reactance of the shunt winding. By placing the shunt winding in series with the armature the motor can be made to run quite satisfactorily.

If one were in possession of data concerning the field ampere-turns, etc., the number of turns for the new winding could be figured easily; but as data are seldom available, it is necessary to use cut-and-try methods.

The writer used 300 turns of No. 26 magnet wire for 12- and 14-in. fan motors with good results. If the speed is too high or the motor heats unduly, more turns should be added, and if the speed is not high enough a few should be cut out. If the motor is provided with a multipoint switch a number of taps may be brought out and so connected that the switch short-circuits more or less of the winding as its position is changed. This will give several speeds without the use of resistance. For these motors, taps were brought out at 300, 350 and 400 turns. The 300-turn tap gave full rated speed and the other two reduced speeds.

The brushes will spark a trifle, but if the regular brushes are replaced by ones of soft graphite composition the commutator will remain smooth and bright. The motor will be somewhat noisy unless the bearing shells are a good fit on the shaft.

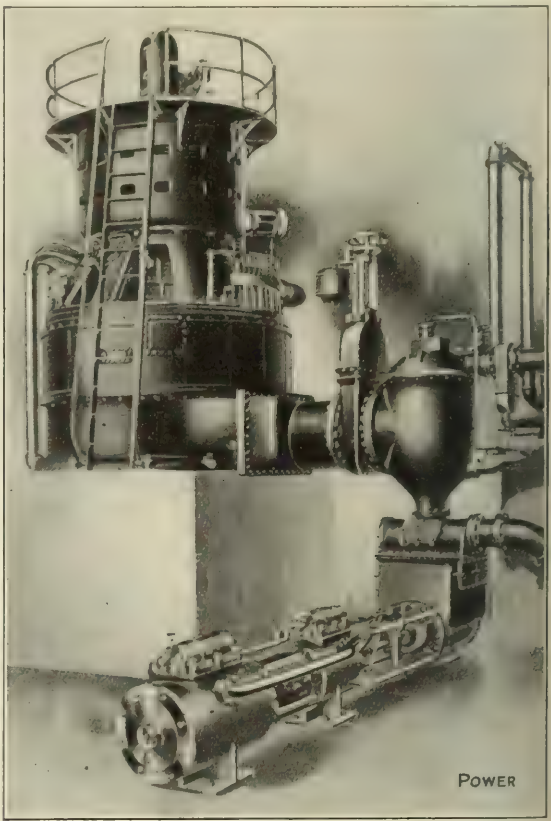
JAMES SPIVENS.

Albuquerque, N. M.

⁂

Location of Vacuum-Breaking Mechanisms

John F. Hurst's conclusion as to the location of vacuum-breaking mechanisms on condensing-engine units, in POWER for Mar. 3, suggests a description of a patented vacuum breaker used in connection with steam turbines and similar high-vacuum service



THE VACUUM BREAKER APPLIED TO A JET CONDENSER

A series of tests having demonstrated the inadequacy of the usual type of float-actuated breaker when dealing with the enormous volumes under high vacuum in turbine work, a type was developed which is dependent upon the difference in absolute pressure on the inside and the outside of the condenser chamber for its operation. The float chamber, which is on the side of the condenser at the desired high-water level, operates a pilot valve, admitting air to and exhausting it from a cylinder fitted with a piston; in turn, the piston actuates the vacuum-breaker valve proper.

Atmospheric pressure is depended on for the operation of the main valve, which, therefore, may be made of any desired size and standard patterns.

The method of application of this breaker may be made to conform to Mr. Hurst's suggestion, but usually, as the consideration of primary importance is the protection of the prime mover from possible injury by flooding, the breaker is placed on the exhaust line as closely as possible to the prime mover. In some cases, the admission of atmospheric air is directly into the low pressure or exhaust chamber of the turbine. Air being admitted at this point, it is obvious that any water which may have flowed back from the condenser into the exhaust-steam line will be ejected.

From the nature of the mechanism it would be entirely feasible to actuate two or even more breaker valves by means of one float. This would permit the installation of a breaker on the exhaust line next to the prime mover and one on the injection line as well.

The photograph shows the device as applied to a condenser unit. The float box will be noticed on the side of the condenser and the vacuum breaker proper on top of the condenser cap. In this instance, atmospheric air is admitted at this point to insure the safety of the rotative dry-vacuum pump as well as the turbine.

It may be said in connection with the operation of one of these breakers that it opens with a sound like the discharge of a shotgun.

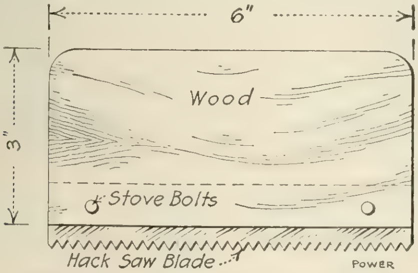
W. M. Fleming.

Holyoke, Mass.

⁂

Slotting the Commutator

Referring to Mr. Stark's letter, in the Apr. 7 issue, on undercutting commutator mica, it would seem that if he had examined the motor he would have discovered that the mica was high at first and would have avoided turning it down three times. We have had considerable experience with sparking and have found in most cases that it was caused by the brushes being off neutral and not ground to fit the commutator or high mica.



Tool for Slotting Commutator

Mr. Stark's method of cutting down the mica is good if the lathe will swing the armature. On large machines the slotting should not be carried too deep as dust will collect between the bars, causing them to throw fire and perhaps produce short-circuits. Also, after a commutator has been slotted it is not good to sandpaper it, as this also allows the sand to collect between the bars with the copper dust and cause flash-overs.

On large machines, Mr. Stark's idea is all right, but it involves baring the engine around for every slot that is cut. A much easier and better way is to make a tool out of a hacksaw blade, putting some tape around one end to form a handle, or making a handle out of wood, as shown in the sketch. To insure a good job, hold a straight piece of iron on the commutator for a guide. The blade can be set to whatever depth it is required to slot.

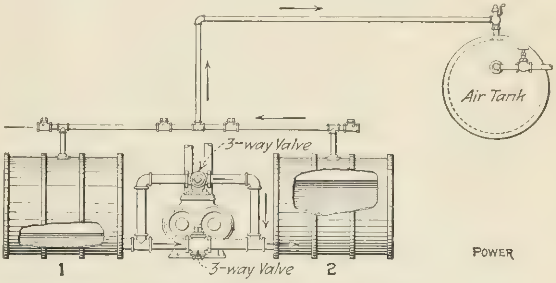
R. G. Curren, Jr.

Kittanning, Penn.

⁂

A Small Air Compressor

We were in urgent need of a small air compressor. An idle steam pump and nearly all the fittings were at hand, so the pump was connected up as shown. Everyone was agreeably surprised at the results.



Pump and Tanks Connected

Any air-tight receptacles, such as oil or plumbers' tanks may be used, but the greater the capacity of Nos. 1 and 2, the fewer the shifts of the three-way valves for a given quantity of air. The capacity of the compressor is equal to its displacement in gallons or cubic feet.

F. W. Hudson.

Ager, Calif.

⁂

How a Municipal Station Was Made to Pay

I was interested in Joseph A. Jeckell's article on the above subject in the Mar. 24 issue, page 412, but I fail to see by what method of bookkeeping the plant was considered as paying 13 per cent. on the capital invested.

According to the summary of results given by him, the capital expended amounted to $1,658,200. This money was evidently expended in new plant and equipment, and for this class of machinery it is usual to charge at least 12 per cent. per annum as fixed charges, which, for this amount, is $198,984 per year. The income per year is given as $298,430, from which, subtracting the above fixed charges, leaves only $99,446, which is under 6 per cent. on the amount invested; so the plant is no bonanza as a money-making proposition, but is earning only an ordinary rate of interest.

As a municipal undertaking it is, however, very commendable, for, generally speaking, these enterprises are not as profitable as they should be, owing to lack of efficient methods in the organization.

G. P. Pearce.

Moline, Ill.

Engineers' Study Course

Elementary Mechanics--IX

Last Lesson's Answers

36. In the triangle $ADEA$, Fig. 34, draw a line DH from the point D to the center H of the side AE. Also draw AF from A to the center of DE. Assume the triangle made up of a series of strips parallel to the base DE and of the form BC. The *c.g.* of this small strip is at its center S, which by construction lies on the line AF. Hence the *c.g.* of the triangle must lie somewhere on the line AF. Again, divide the triangle into a series of small strips parallel to the line AE and of the form MN. The *c.g.* of these small strips will fall along the line DH. Therefore, the *c.g.* of the triangle will be at the point of intersection G of the two lines DH and AF.

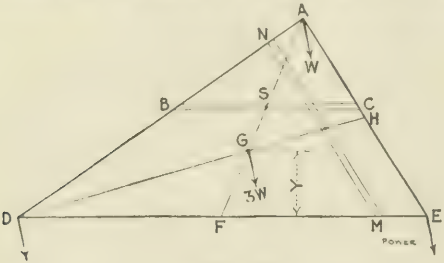


FIG. 34.

The *c.g.* might also be found by assuming equal weights W suspended from the vertices A, D and E of the triangle and then taking the moments of these weights about the base of the triangle. The moment arm of the weight W at the point A will be the altitude of the triangle. Let Y equal the distance from the base DE to the *c.g.* located at point G and take moments about the base DE, thus

$$W \times \text{altitude} = 3 \times W \times Y$$

or

$$Y = \tfrac{1}{3} \text{ the altitude}$$

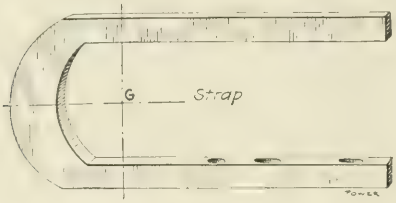


FIG. 35.

Hence *the center of gravity of any triangle is at a distance of one-third the altitude from any and all bases.*

37. Not always; as an example see Fig. 35, which shows the strap of a connecting-rod. The *c.g.* of the strap lies near the point G.

38. Before the plate was punched the *c.g.* was at the point O (see Fig. 36) or at the center of the diagonal AB. The punched plate is symmetrical with respect to the line AB. Assume the *c.g.* at the point G distance X inches from the point O. It can readily be shown that the distance from the point O to the center of the hole C is 2.12 in. The area of the punched plate is 225 − 12.57 = 212.43 sq.in. The moment about the point O of the *part cut away must equal the moment of the part remaining.* Thus

$$X \times 212.43 = 2.12 \times 12.57$$

or

$$X = \tfrac{1}{8} \textit{ in. (approx.)}$$

39. The weight of a 6-in. cast-iron ball is about 30 lb. and the weight of a 2-in. rod, 18 in. long is 16 lb. The *c.g.* of the rod is 9 in. from the end, and the *c.g.* of the ball is 21 in. from the end, of the rod. Let X equal the distance from the end of the rod to the desired *c.g.* Take moments about the end of the rod, thus

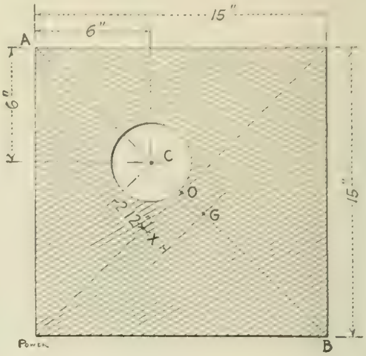


FIG. 36.

$$9 \times 16 + 21 \times 30 = 46 \times X$$

or

$$46 \times X = 774$$

and

$$X = 16.8+ \textit{ in.}$$

40. The *c.g.* will lie in the vertical axis CY of the frustum, Fig. 37. The *c.g.* of the cone from which the frustum was formed was ¼ the altitude (2 in.) from the base EF or at the point B. The *c.g.* of the part of the cone which was cut away, was 1 in. from the base MN. Let the *c.g.* of the frustum $MNFEM$ be located at the point G, X inches from the point B. To find the value of X take moments about the point B.

Thus,

$$16.76 \times 3 = 117.29 \times X$$

or

$$X = 0.43 \textit{ in.}$$

Therefore, the *c.g.* of the frustum $MNFEM$ is on the line CY 1.57 in. from the base EF. (Note—Volume of $MCNM$ = 16.76 cu.in.; volume of $MNFEM$ = 117.29 cu.in.)

CENTER OF GRAVITY—*Continued*

In problems where the body is symmetrical with neither the vertical nor the horizontal axes the following general method must be applied to find the *c.g.* Assume a given body to be divided into a large number of very small parts, and the weights of each part to be represented by the points w_1, w_2, w_3, etc., as shown in Fig. 38. Locate each of these weights from the axes OX and OY. thus

w_1 is x_1 units from the OY axis, and y_1 units from the OX axis. The resultant of all these small weights will be the total weight W of the given body. Thus $W = w_1 + w_2 + w_3 + \ldots$, etc. This weight or resultant will act at the *c.g.* of the body. Let this point be X units from the OY axis and Y units from the OX axis. Then the distance Y may be found by taking moments about the axis OX. Thus

$$w_1 y_1 + w_2 y_2 + w_3 y_3 + \ldots = (w_1 + w_2 + w_3 + \ldots) Y = WY$$

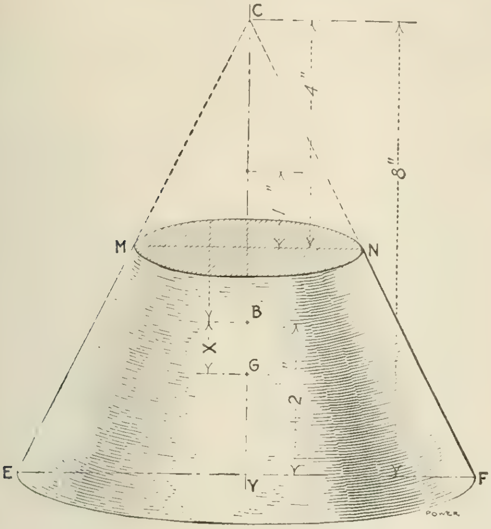


Fig. 37.

$$\text{or} \qquad Y = \frac{w_1y_1 + w_2y_2 + w_3y_3 + w_4y_4 + \ldots}{w_1 + w_2 + w_3 + w_4 + \ldots} \qquad (11)$$

In like manner the value of X may be found by taking moments about the OY axis. Thus,

$$X = \frac{w_1x_1 + w_2x_2 + w_3x_3 + w_4x_4 + \ldots}{w_1 + w_2 + w_3 + w_4 + \ldots} \qquad (12)$$

If all the weights cannot be located in the plane of the OX and the OY axes, a third reference axis may be used and then.

$$Z = \frac{w_1z_1 + w_2z_2 + w_3z_3 + w_4z_4 + \ldots}{w_1 + w_2 + w_3 + w_4 + \ldots} \qquad (13)$$

Stable and Unstable Equilibrium

If a slight horizontal force P be applied to the cone shown in Fig. 39 so as to raise the point C, and then if the force P be removed it is evident that the cone will return to its original position. When the force P is removed the weight W forms with the reaction at the point B, a couple which brings the cone back to its former position. If, however, the force P had been applied until the line GW fell outside of the point B, then the cone would have overturned, for in this case the weight W would form with the reaction at the point B a couple which would rotate the cone in a counter-clockwise direction which, of course, would overturn the cone.

Therefore, a body is said to be in stable equilibrium when, if it be slightly displaced from its initial position, the forces acting on the body tend to bring it back to its original position: or the body is in unstable equilibrium if, after being slightly displaced, the forces acting tend to still further move it from its original position.

If, after the body is slightly displaced, the forces are in equilibrium, the body is said to be in neutral equilibrium. Thus in Fig. 39 when the force P is applied, the *c.g.* of the cone rises until the point G is in the same vertical line as the point B, then further application of the force P causes the *c.g.* to be lowered. Assume the cone to be resting on its slant height AB, then any displacement of the body will neither lower nor raise its *c.g.*

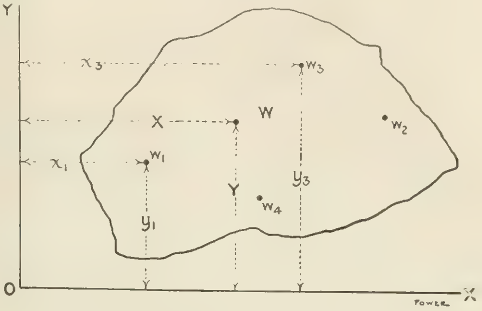


Fig. 38.

Hence the following rule may be applied to test the kind of equilibrium: *If a slight displacement of a body raises its c.g. the body is in stable equilibrium, if the displacement lowers the c.g. the body is in unstable equilibrium, and finally if a slight displacement neither raises nor lowers the c.g. then the body is in neutral equilibrium.*

Still another test is this, if a vertical line drawn through the *c.g.* of the body falls within the plane of support the body is in stable equilibrium and if it falls outside the body is in unstable equilibrium.

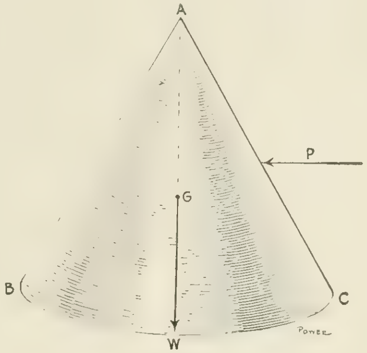


Fig. 39.

Example—A ball resting on the ground is in neutral equilibrium for its *c.g.* remains at a fixed distance from the ground. An engine bed resting on its foundation is in stable equilibrium, for if its *c.g.* be raised the bed will return to its position when the force is removed.

Study Questions

41. The one leg of a standard angle is 6 in. and the other leg is 4 in. If the thickness of the legs is ¾ in., locate the *c.g.* by using equations (11) and (12).

42. In what kind of equilibrium is a horizontal beam which is being raised by a rope attached at its center?

43. Give two illustrations of neutral equilibrium.

44. For the most stable equilibrium, should the *c.g.* of a coal truck be high or low?

45. The drum head of a B. & W. boiler rests on its curved surface. In what kind of equilibrium is it?

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

We thank Brother McEachren, of the bright and useful "Valve World," for his kindly references to "Power." We try to be modest and humble, but being only human, we are pleased by the kindly word and the sincere praise.

P. S.—Of course, this will not prevent our returning a closely written twelve page "artlcle" digested from old "Power" files to the feller who begins: "OH, HOW I LOVE MY POWER!' Please print this at your regular rates." You get this, feller?

*

An "Arbeitswillige" is a man who is willing to work, "Coal Age" tells us. It appears to be a Teutonic toning down of those obnoxious epithets "scab" and "rat." We have no quarrel with the first few syllables but "swill"—this is altogether too garbageous! (There's a copyright on this word.—Editor.)

*

When there's fighting to be done by our navy folks, everybody takes a hand in it—from the quarter deck down to the stokehole. The daily press is full of Coalpasser Smith's bravery and judgment in an emergency.

*

Because the power was off the Hudson & Manhattan system recently for a few minutes, a newspaper wisegink said "an oil-switch jammed the turbine." Awk! and two arfs!

*

Here's food in the raw for optimism. The good old wheat crop has reached a billion bushels this year! Of course, rye and corn have done quite well, but we're not particularly interested in them; that is, in the raw. Take this in the "spirit" in which it is given.

*

Pure-Fooder Wiley has advanced the best reason yet for the eight-hour law: "It gives men time to do other things besides work." The few power-plant engineers who have heard rumors of the existence of an eight-hour law will please raise their right hands. The "noes" have it.

*

"Bugs May Come and Bugs May Go, but Germs Hold On Forever," is the title with a Tennysonian touch of a paper to be read at the American Water Works convention. Might try a half-Nelson or a strangle-hold, or get 'em off their guard with a piece of cheese.

*

Hope you read that "Candid Chat" in this issue wherein it is contended that the five-spot you bank today is as big as the hundred you MEAN to save out of next week's earnings. Here's a good argument in its support. In the savings banks of New York state the wage earners have one billion seven hundred and fifty million dollars saved by a little economy and forehandedness.

*

THE OLD WOODEN BARROW

(Tune: "The Old Oaken Bucket")

By **Billy Spills**

How near to our hearts are the scenes of young manhood
When pained recollection presents them to view,
The plant-yard, the coalpile, the wreck of a barrow
That wheeled in the coal. Oh, those days we once knew!
'Twas young we were, strong we were, eager and willing,
But gee! that old barrow did worry us hard.
If pushed straight ahead, the old barrow went sideways,
It tipped up, and rared up, and balked in the yard.

(Chorus)
The old wooden barrow, that busted old barrow,
The barrow we swore we would pitch in the well.

'Twas leaky, and squeaky, had one leg to stand on—
No man could remember it ever had two.
It man-shied, and coal-shied, and skidded and wabbled;
It hit every rock that presented to view;
And always, 'twixt earth and the blue and high heaven
It stopped on the plank—and prepared to depart!
But, brothers, the days of the barrow are over,
So let us join hands and sing out from the heart:

(Chorus)
The old wooden barrow, our lives it did harrow,
But—Here's to the barrow we'd pitch in the well!

Value of Filtered Oil

SYNOPSIS—When properly filtered, oil can be used repeatedly and the tests show that it loses none of its lubricating properties. Excessive filtering surface is unnecessary if efficient precipitation is provided for.

*

To determine what deterioration oil suffered from use, a series of comparative tests of used and unused oils was made on different samples of oil at the laboratories of Cornell University. From those tests it may be concluded that if oil is properly filtered, it can be used repeatedly without losing any of its lubricating qualities.

Data secured from tests of oils used at the power plant of the Hotel McAlpin, New York City, are here selected as representing severe operating conditions.

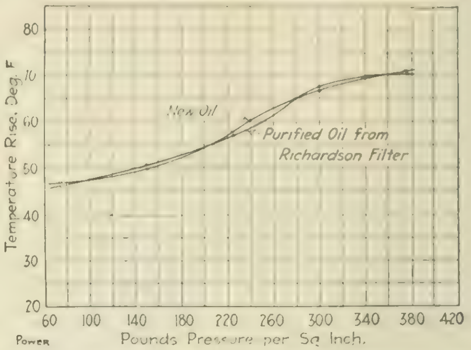


Fig. 1. Temperatures of Bearing above Room Temperatures

This plant is equipped with an oiling and filtering system which supplies flooded lubrication to four Corliss engines, three air compressors and one crank-and-flywheel pump having a total of 134 points of lubrication. The plant operates 20 hours per day, and the average temperature of the engine room is 100 deg. F. On account of the great variety of machines lubricated, the high load factor and the exceptional temperature conditions, the work is probably representative of average power-plant conditions. The oil was a good grade of mineral engine oil.

Observations showed that the average amount of oil handled by the lubricating system was 150 gal. per hour, or 3600 gal. per day, which is equivalent to 1800 barrels per month. Although this amount of oil is continuously supplied to the bearings, only three barrels of oil per month are added to the system. Even this cannot be charged to natural shrinkage in the system, as large quantities of oil are drawn off from the filters and used in cans for hand-oiling of small pumps, valve gears and bearings not connected to the oiling system.

To determine the changes undergone by the oil, a sample of the new oil as received in barrels from the manufacturers was secured and also a sample of the oil drawn off from the clean oil compartment of the filter. These samples were sealed and shipped to the testing department at Cornell University, and subjected to a series of tests under the supervision of Professors Carpenter and Sawdon, the results of which tests are given in the accompanying tables and curves.

A series of friction tests were made on a Thurston railroad lubricant tester, having a hardened-steel journal and bronze bearings with a total area of 20 square inches. In all tests the machine was run at a constant speed of about 360 r.p.m. and the load applied in increments of 1500 pounds total pressure or 75 pounds per square inch. The test at each load was continued until the friction and temperature of the bearings had become constant. The oil was fed upon the

TABLE 1. SAMPLE "A." NEW OIL

Press. on bearing, total lb.	1500	3000	4500	6000	7500
Press. on bearing, lb. per sq.in..	75	150	225	300	375
Duration of test, min....	120	50	60	60	50
Temperature of bearing, max..	114.5	120.0	129.5	139.0	143.5
Temperature of room, aver....	68.2	70.7	71.5	72.5	73.0
Diff. in temp. bearing and room	46.3	49.3	58.0	66.5	70.5
Rate of feed, drops per min. aver.	34.8	38.4	33.6	37.0	38.2
Speed, r.p.m.	362	361	361	361	359
Speed, ft. per min.	355	354	354	354	352
Minimum coeff. of friction..	0.01166	0.00666	0.00533	0.00458	0.00373

side of the bearing through a sight-feed oiler and the feed maintained as nearly constant as possible throughout all the tests. Readings made at ten-minute intervals are summarized in tables 1 and 2.

The coefficients of friction shown in Tables 1 and 2 represent the lowest value found for each load; that is, as soon as a given load is applied the coefficient at first high, gradually falls off until it becomes practically constant. This latter coefficient corresponds to those shown in the tables and represents the values that would obtain in ordinary practice where engines operate continuously for more than an hour. The temperature readings given in the tables are the highest reached for each load, that is, as each new load is applied, the bearing gradually heats up until the temperature becomes practically constant.

The differences in temperature between the bearing and the room have been plotted in the curves shown in Fig. 1, Curves showing the coefficients of friction of the new and filtered oil are shown in Fig. 2.

TABLE 2. SAMPLE "B," FILTERED OIL

Press. on bearing, total lb.	1500	3000	4500	6000	7500
Press. on bearing, lb. per sq.in.	75	150	225	300	375
Duration of test, min.	150	60	60	80	50
Temperature of bearing, max..	120	125.5	132.5	144.5	147.2
Temperature of room, aver....	74	74.8	75.3	77.0	77.5
Diff. in temp. bearing and room	46	50.7	57.2	67.5	69.7
Rate of feed, drops per min. aver.	38.9	40.3	37.4	40.5	41.4
Speed, r.p.m.	363	363	360	361	358
Speed, ft. per min.	356	356	353	354	351
Minimum coeff. of friction....	0.01265	0.00717	0.00522	0.00458	0.00367

The question naturally arises, what physical changes if any, has the oil undergone during this extended period?

The results of tests made to determine this are given in Tables 3 and 4:

TABLE 3. PHYSICAL PROPERTIES, SAMPLE "A," NEW OIL

Color: medium red, translucent.
Flash point: 410° (open cup).
Burning point: 460° F. (open cup).
Specific gravity at 60° F. water as 1 = 0.895.
Viscosity (with Olsen viscosimeter).
Water as 1 at 60° F. Time 27.9 secs. for 100 cc.

Temperature F.	Time 100 cc. Secs.	Relative Viscosity
70	97.6	3.48
70	96.6	3.46
71	96.2	3.45
97	59.8	2.14
94	61.8	2.21
130	45.6	1.63
132	43.8	1.57
214	34.0	1.22
215	34.2	1.225

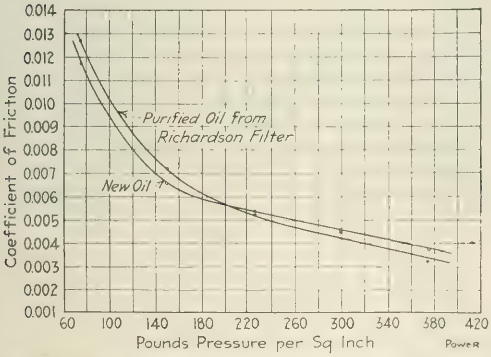


FIG. 2. COEFFICIENTS OF FRICTION WITH VARIOUS BEARING PRESSURES

TABLE 4. PHYSICAL PROPERTIES, SAMPLE "B," FILTERED OIL

Color: very dark red, opaque.
Flash point: 410° F. (open cup).
Burning point: 440° F. (open cup).
Specific gravity at 60° F. water as 1 = 0.903.
Viscosity (with Olsen viscosimeter).
Water as 1 at 60° F. time 27.9 secs. for 100 cc.

Temperature F.	Time for 100 cc. Secs.	Relative Viscosity
68.0	138.0	4.94
69.0	134.0	4.80
70.0	130.2	4.66
103.0	60.4	2.16
114.0	50.6	1.81
130.0	45.2	1.62
152.0	39.0	1.40
147.5	40.2	1.44
218.0	33.2	1.19

The viscosity readings are shown plotted in Fig. 3.

From comparison of the tables it would appear that the use of the oil increased its specific gravity. This is to be expected as the oil, in passing through the bearings, has had some of its more volatile constituents driven off; also, because a small quantity of cylinder oil used for lubricating the piston rods and stuffing boxes finds its way into the oiling system. The viscosity curves also confirm this hypothesis as the tests show that the used oil has a higher viscosity than the new, demonstrating that as oil is used over and over in an oiling system it actually gains in body, provided, of course, the filter thoroughly removes entrained water.

The results of the friction tests shown in Fig. 3 are also consistent with these physical changes, and it is to be noted that the new oil shows a slightly lower coefficient of friction on low bearing pressures. This may be because the old oil, having more body, is better able to maintain a lubricating film when subjected to higher pressures. The difference between these two curves is so slight that, for all practical purposes, it may be concluded that under average operating conditions properly filtered oil is quite as good a lubricant as new oil.

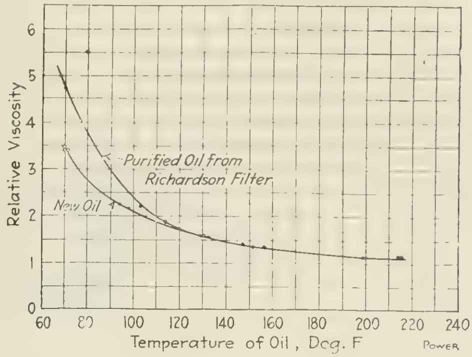


FIG. 3. RELATIVE VISCOSITY, NEW VS. PURIFIED OIL

The curves shown in Fig. 1, are probably the ones that will be most interesting to the operating engineer, as it is usually by the temperature of the bearings that he determines the condition of lubrication. It may be noted that these curves are practically superimposed and in no case is the variation more than a few degrees, indicating, from temperature rise, that properly filtered oil should be as good as new oil.

The above data was furnished by the engineering department of the Richardson-Phenix Co., lubrication engineers and manufacturers, Milwaukee, Wis.

⁂

Explosion of a "Safety" Water-Tube Boiler

The photographs herein reproduced are the best we have been able to secure showing the wrecked boiler and surrounding buildings at the Drummond Collieries at Westville, N. S., brief mention of which appeared May 5, on page 652.

Fig. 1 is a general view of the wrecked boiler house; A shows the position of the boiler before the explosion; B, the relative position of the larger part of the boiler after the explosion, and C the building through which the front head and water leg went. Figs 2 and 3 are views of the same part of the rear portion B of the boiler from different angles. Fig. 4 shows one of the remaining boilers.

From the reports at hand it appears that the longitudinal seam on the front course of the steam drum failed throughout its length. This sheet straightened out almost flat, tearing entirely away from the front head and water leg, and also at the circumferential seam joining it to the second course, leaving the boiler proper in four parts, viz., the rear water leg and two courses of plates attached (which were hurled 140 ft. from its setting); the front sheet; the front water leg and the front head which separated and were thrown about 100 ft. in the opposite direction.

The shell was 48 in. in diameter by 19 ft. 5 in. long, and was made of ½-in. plates. There were 116 four-inch tubes. The boiler was not insured nor subject to other inspection. The coroner's inquest brought out the following statements:

F. G. Murphy, mining engineer, instructor at the Technical College, Halifax, gave the result of his test of the plate, as to its ductility. The maximum load was 65,970 lb., and the

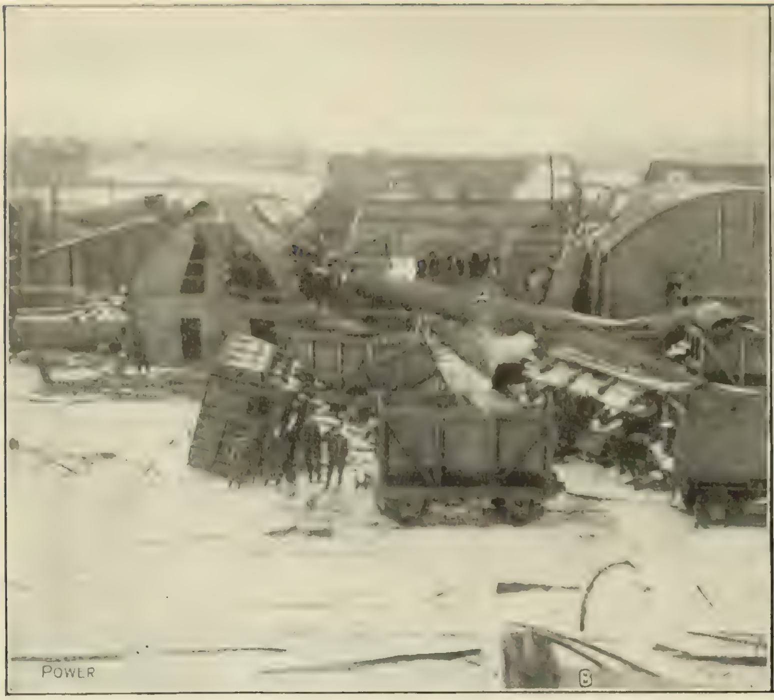


FIG. 1. GENERAL VIEW OF SURROUNDINGS

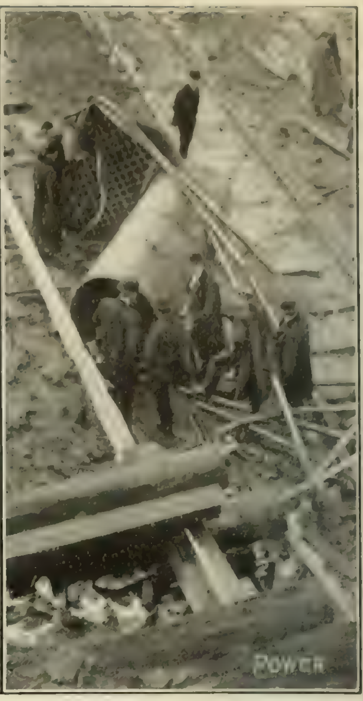


FIG. 2. REAR SECTION

FIG. 3. SAME SECTION AS FIG. 2.

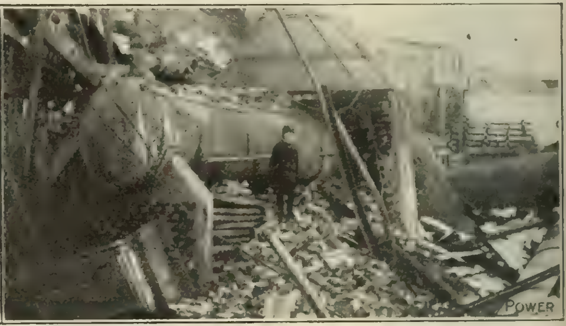


FIG. 4. ADJOINING BOILER

yield point was 57,930 lb., which acted more like a high-carbon steel than a mild boiler steel, the yield point of which should be about 33,000 lb. His chemical test showed carbon, 0.15; phosphorus, 0.055; sulphur, 0.049; manganese, 0.61.

T. W. Hardy, analytical chemist, Nova Scotia Steel Co., said his test showed carbon, 0.16; phosphorus, 0.058; sulphur, 0.047, and manganese, 0.64. A physical test gave elastic limit, 44,220 lb.; the breaking strain, 64,979 lb.; elongation, 18.62 per cent.; reduction, 45.51 per cent.

William Macfarlane, New Glasgow, foreman boiler maker for I. Matheson & Co., said when asked as to the cause of the explosion: "I found that the boiler gave at the longitudinal seam. So far as I could see, it was a crack in the making; that the plate was cracked in the rolling, just the skin of the plate; there would be no way of seeing it; the contraction and expansion would make it worse."

W. G. Matheson said: "I would not use it. In proper samples, the carbon runs from 0.18 down to 0.14, so you see 0.16 is a fair average. The phosphorous should run from 0.029 to 0.010. There is a good deal of difference between this and 0.047, which is what the sample from the exploded boiler gives.

"Sulphur should run from 0.039 to 0.026. We want the limit to be 0.035, although a little higher does not do much harm provided the phosphorus is low.

"Manganese should run from 0.43 at the highest to 0.35; we want to see it under 0.60. Boiler plates having such percentages of phosphorus, sulphur and manganese would be too high, as shown, in the elastic limit, which runs up to 44,220 lb., according to our test." He thought that the crack caused the explosion, and that the cause of the crack was the brittle plate.

⁂

Gasoline-Electric Locomotive—A petrol-electric locomotive crane has recently been constructed in Germany at the Aktiengesellschaft Lauchhammer at Lauchhammer. The motive power is furnished by a 40-hp. petrol engine coupled direct to a continuous-current dynamo having a capacity of 23 kw. at 230 volts. The machine runs on eight standard-gage wheels, each of the inner axles being driven by a 12½-hp. electric motor through bevel-reducing gear. The rotating crane has a capacity of two tons and a radius of action of 32 ft., the cable drum being operated by an 8-hp. motor.

⁂

Errata—In the article on "Refrigeration Plant Troubles and Remedies" in the May 5 issue, line 14, first column, page 634, should read: Thus we need 126 × 3.6 = 453 lb. of new aqua ammonia of 26 deg. density.

POWER

Vol. 39 NEW YORK, MAY 26, 1914 No. 21

Another Popular Misconception

"WHY, I THOUGHT ALL ENGINE ROOMS WERE DIRTY!"

Plant Serving St. Louis Railway Exchange Building

By Thomas Wilson

SYNOPSIS—A 2250-kw. plant supplying both alternating and direct current at five different voltages. Its special features are coal- and ash-handling equipment, the breeching arrangement and the noncondensing, single-stage turbines.

◆

The Railway Exchange Building, of St. Louis, commonly referred to as the most spacious office edifice in the world, is a 22-story structure measuring 228x274 feet, and 308 feet high. The first seven floors are occupied by the Famous & Barr department store and the remainder is given over to railway and general offices. The total floor space aggregates 33 acres as compared to 25 acres for the Hudson Terminal Buildings of New York, and the contents are 15,500,000 cu.ft. against 13,000,000 for the Woolworth Building.

To furnish this enormous building with heat, light, power and refrigeration, are the chief functions of the latest power plant of the Cupples Station Light, Heat & Power Co., which is in the basement of the Kingston Building, over a block away. The plant also supplies a number of smaller business houses with heat, light and power. During the shopping hours the load averages from 1200 to 1400 kw., divided about half and half between light and power. A peculiarity of the service is that the electrical energy is both alternating and direct current, at three different voltages for the former and two for the latter. There are other interesting features, such as the coal- and ash-handling systems, steam outlets at the low end of the boilers and flow meters to measure the steam from each boiler, superheating tubes in the uptakes, special breeching arrangement, and single-stage, noncondensing turbines. The plant has a total of 2052 hp. in boilers, 2250 kw. in generating units, with pro-

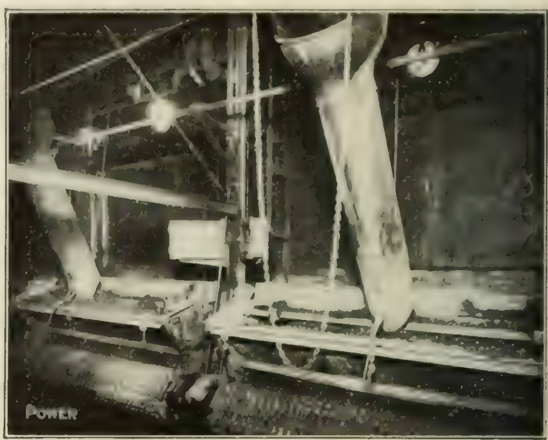


Fig. 2. Two of the Water-Tube Boilers

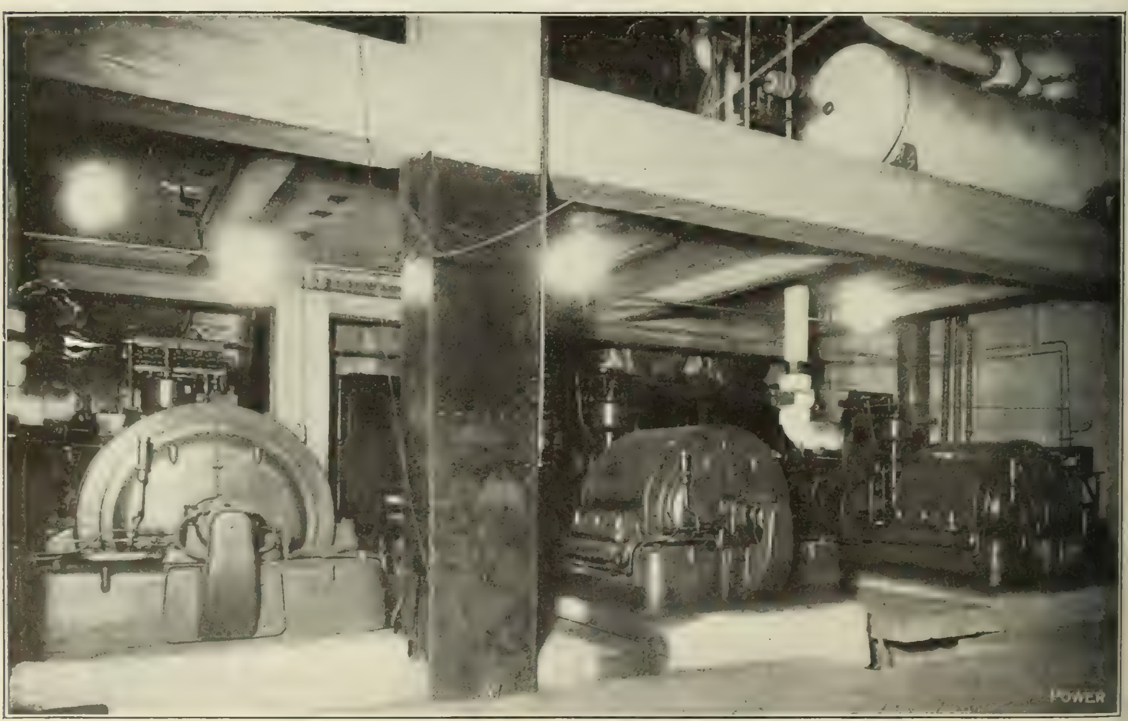


Fig. 1. The Three 750-Kw. Single-Stage Turbine Units

vision for an additional 750-kw., and 100 tons of refrigeration. It supplies exhaust steam for 250,000 sq.ft. of radiation during the day; live steam being used at nights in the colder weather. Steam under 40-lb. pressure is supplied for cooking purposes.

BOILERS

There are four 513-hp. Heine boilers, Fig. 2, each containing 5134 sq.ft. of heating surface in two 42-in. drums, 22 ft. long and 296 tubes, 3½ in. in diameter. Green chain-grate stokers of the inclined type containing 110 sq.ft. of grate area serve the boilers, giving a ratio of grate to heating surface of 1 to 47. In each uptake is a Foster bare-tube superheater containing 1461 linear feet of 2-in. pipe, in which is a 1-in. core to force the steam to the outer wall and present a thin layer to the action of the gases. The superheater was designed to give 50 deg. of superheat with the steam at 200-lb. pressure and the entering flue gases at 600 deg. F. In operation, only 32 deg. of superheat has been obtained, but this is probably because the working pressure is 225 lb. and the flue gases do not exceed 550 deg. in temperature when the boilers are forced 50 per cent. above rating.

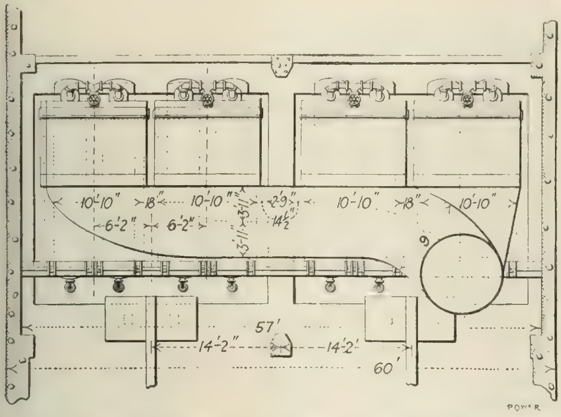


FIG. 3. PLAN VIEW OF BOILERS, SHOWING BREECHING ARRANGEMENT

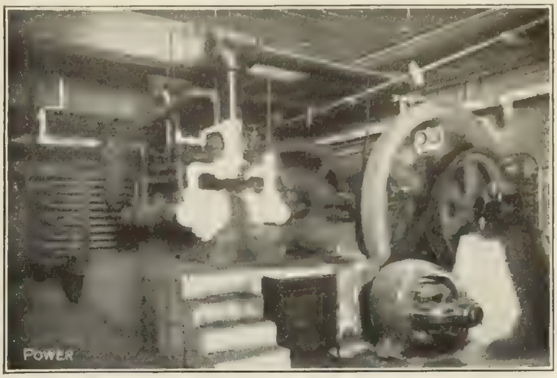


FIG. 5. TWO 50-TON AMMONIA COMPRESSORS AND DOUBLE-PIPE CONDENSER

As shown in Fig. 3, the breeching has been made with easy curves and baffles have been so arranged that the gases from one boiler will not interfere with those from the boiler back of it. When the gases unite, they are flowing in the same direction and the area of the breeching has been proportionally increased. About 16 sq.ft. of breeching area per boiler has been provided, making a total of 64 sq.ft. at the stack which is 9 ft. in diameter and has an area approximating that of the breeching. The stack or total breeching area bears a ratio to the connected grate surface of 1 to 7. In good practice a ratio of 1 to 5 is common, so that in the present case, it is evident that ample provision has been made for overload capacity; besides, the effective area of each grate is probably less than 110 sq.ft., so that the ratio would be reduced. The stack rises 300 ft. above the grates, and at the uptake of the farthest boiler a draft of 1½ in. of water is available. Over the fire the draft intensity is only one-third of the above figure due to the resistance offered to the flow of gases by the superheater and the boiler setting. The steel stack is self supporting, rests on an I-beam frame work at the base and is provided with a slip guide tied into the steel work of the building at the roof. In front the boilers are suspended from I-beams, and at the rear rest on rollers held in place by a chair construction supported on brick piers.

A steam outlet at the low end of a Heine boiler is unusual and special precautions must be taken to obtain dry steam. In the present case a 6-in. dry pipe suspended from the shell is carried to the front of the drum, where steam is admitted through 100 one-inch holes bored in the top of the pipe. At the outlet a steam pot has been provided to receive any moisture carried along with the steam, and this is drained through a 1¼-in. pipe leading out of the drum. A deflecting

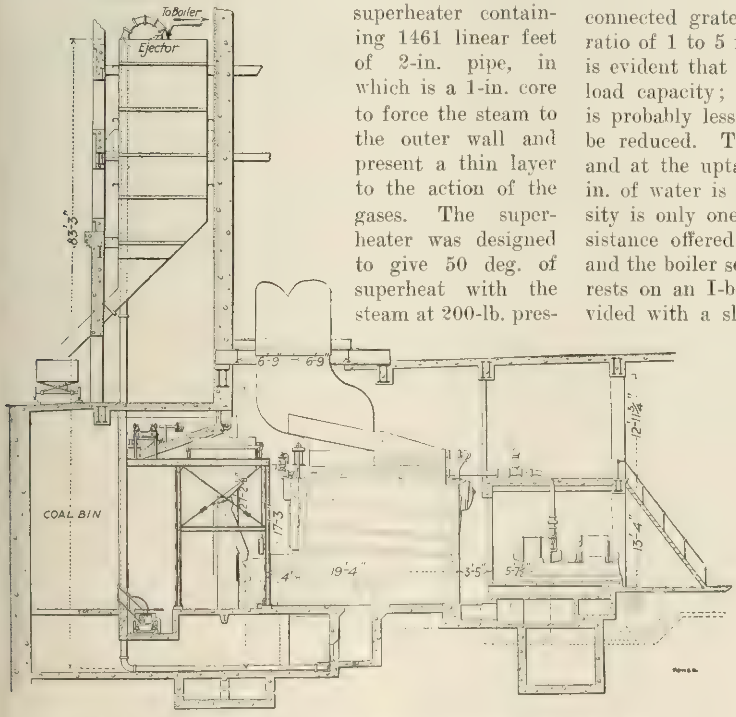


FIG. 4. SECTIONAL ELEVATION THROUGH BOILER AND TURBINE ROOM

plate over the front water leg turns the circulation toward the rear and prevents any water in suspension from reaching the outlet.

Ordinarily, two boilers are required to carry the day load and at times three are necessary, leaving the fourth unit as a spare to be called into service at times of repair or cleaning. A feature is the installation in the steam line from each boiler of General Electric indicating flow meters. These instruments show what the boilers are doing at any time and indicate the proportion of the load each is carrying. The plant is also equipped with a 2000-hp. Cochrane heater with a V-notch and recording meter to measure the water fed to the boilers at a temperature of 210 to 212 deg. Centrifugal feed pumps are used, one being turbine driven and the other two connected to motors. The turbine unit has a capacity of 175 gal. per min., which is sufficient for the four boilers. Each of the motor-driven pumps has a capacity of 100 gal. per min. Ordinarily they are held as reserves, and are only put into service at times of light load when the demand is considerably below the capacity of the steam unit. Naturally, the piping is so arranged that any pump can supply any boiler.

Coal Handling Equipment

Coal is delivered to the plant in wagons and dumped into a 250-ton bin in front of the boilers. As shown in Fig. 4, the coal falls from the bin by gravity into an Alvey Ferguson pivoted bucket coal conveyor which carries the coal to the top of the boiler room and dumps it into individual screw conveyors delivering to seven-ton hoppers in front of each boiler. From this temporary storage, the coal is chuted to the stokers. The hoppers are mounted on scales with the indicating dial carried down to a readable position. About 134,000 lb., 67 tons, of coal are burned per day. The fuel used at the present writing is 2-in. Illinois screenings not exceeding ten thousand B.t.u. per lb. Table 1, a consolidated report of the coal analyses for January and February, will give a good idea of the character of the coal.

To dispose of the ashes a Green pneumatic system was installed. This consists of a large ash tank extending from the second to the fifth floor of the building, an exhauster and dust collector on the roof and the necessary piping connecting the tanks to the furnace ashpits. An 18-in. galvanized-iron pipe connects the dust collector and exhauster with the ash tank. When the fan is in

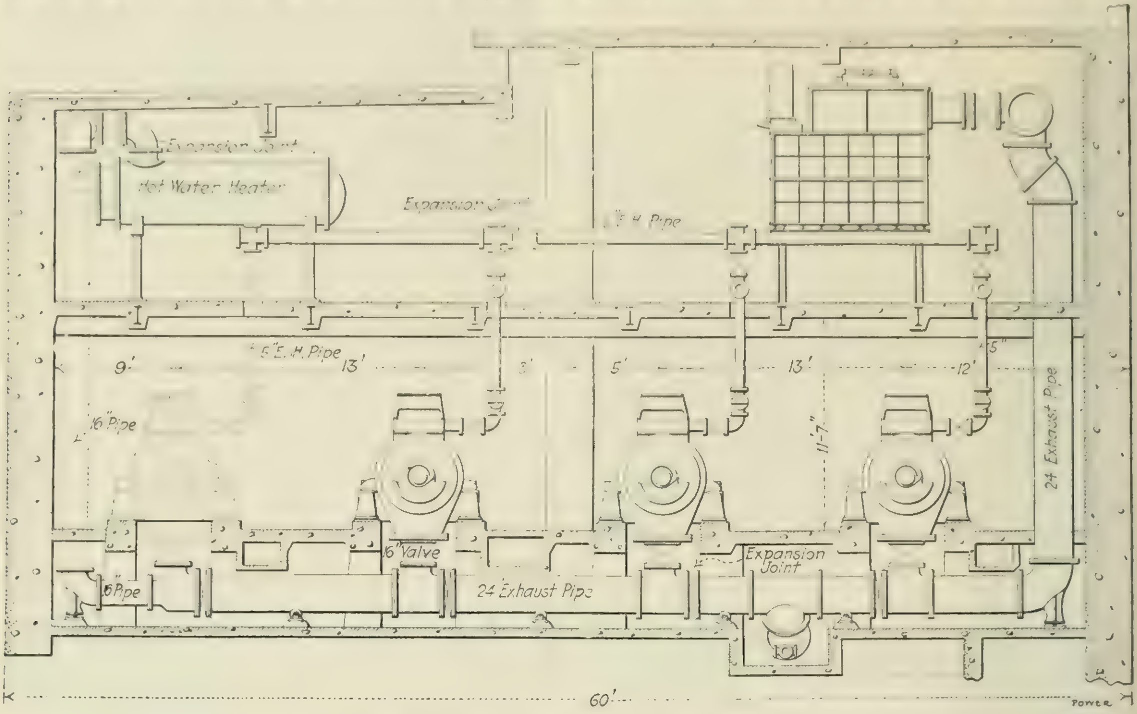


Fig. 6. Piping to and from Turbines

TABLE 1 COAL TESTS FOR JANUARY AND FEBRUARY 1914

Grade	Sampled at Date	Total Moisture Per Cent.	Moisture in Dried Sample Per Cent.	Volatile Matter Per Cent.	Fixed Carbon Per Cent.	Ash Per Cent.	Sulphur Per Cent.	B.t.u. as Fired per Lb.	B.t.u. Dry per Lb.
Washed screenings, No. 5	12-28-13	39.30	2.20	34.00	45.70	18.00	3.83	6,561	10,757
No. 4 screenings	1-14-14	15.83	3.70	37.90	44.40	14.00	3.70	10,062	11,701
2-in. nut	1-14-14	11.24	6.90	37.10	44.80	11.20	3.50	11,259	12,685
Unwashed screenings	1-30-14	13.37	4.20	31.60	38.00	26.20	6.51	8,001	9,047
Unwashed screenings	2-7-14	12.40	6.40	31.30	39.10	23.20	6.00	8,937	10,260
Unwashed screenings	2-7-14	14.80	4.90	33.60	38.10	23.40	4.80	8,796	10,318
Unwashed screenings	2-9-14	14.62	4.40	34.10	37.40	24.10	7.00	8,545	10,008
Unwashed screenings	2-10-14	12.54	6.70	30.40	37.20	25.70	5.50	8,123	9,288
Unwashed screenings	2-14-14	16.60	7.60	34.80	42.00	15.60	3.80	9,409	11,282
Unwashed screenings	2-19-14	17.00	4.90	34.30	39.50	21.30	7.36	8,507	10,248
Unwashed screenings	2-20-14	18.00	7.50	32.40	38.30	21.80	6.80	8,095	9,873
Unwashed screenings	2-25-14	15.00	5.20	31.60	39.30	23.90	5.30	7,650	9,000
Unwashed screenings	2-27-14	15.40	9.10	32.40	42.20	16.30	5.40	8,992	10,629
Unwashed screenings	2-28-14	14.00	7.20	32.80	42.90	17.10	5.00	9,162	10,654

operation a partial vacuum is created in the system and air at high velocity is drawn through the extra-heavy 6-in. pipe leading from the ashpits into the top of the tank. The ashes are scraped from the pits into ash pans through which they are introduced into the pipe and are carried along with the current of air. The tank has a capacity of 30 tons. In a system of this kind, the wear on the piping at the turns is excessive. The original installation had been provided with standard elbows, but later they were replaced with elbows of long radius to lessen the abrasive action of the ash. A Girtanner-Daviess $\frac{5}{8}$-in. steam nozzle was also installed at the turn leading into the tank, the latter to serve in the same capacity as the exhauster. The original system was left intact, however, so that either the exhauster or the nozzle may be used. It is customary to place the nozzle at the lower turn in the pipe line so that part of the action is induced and part is positive. In the present case a lift of 90 ft. is effected by suction with equal satisfaction. The horizontal run is 75 ft. long, and the ashes from the farthest boiler travel 165 ft. before reaching the tank. As the steam puts out the fire in the ashes and prevents clinkering, there is no trouble in removing them from storage. A chute leading from the bottom of the tank to the alley discharges the ash into wagons.

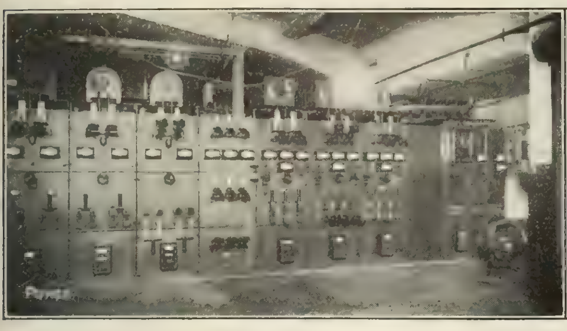


Fig. 7. Eleven-Panel Switchboard

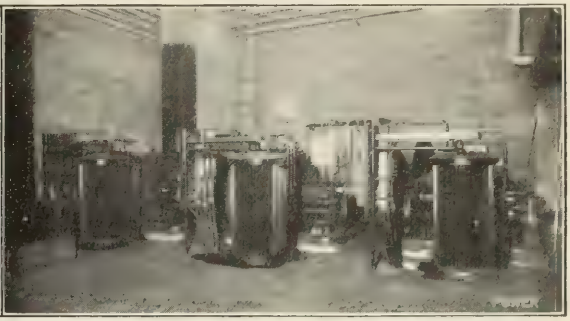


Fig. 8. Transformer and Rotary Converter

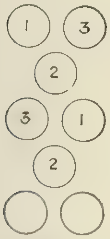


FIG. 9

Arrangement of Ducts

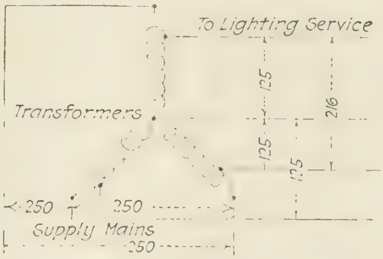


FIG. 10

Obtaining 125-Volt Lighting Service From 250-Volt Supply

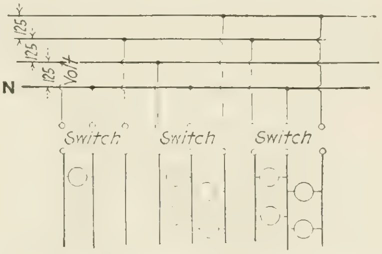


FIG. 11—Distribution of A.C. Lighting Circuits

Conduits and Wire Arrangement

At present, the plant is equipped with three 750-kw. units consisting of single-stage, General Electric horizontal turbines driving directly at 3600 r.p.m. three-phase 60-cycle 250-volt generators, Fig. 1. Two units carry the load, leaving the third as a reserve. Provision has been made for the installation of a fourth of the same size as soon as the load makes this necessary. There are two 25-kw. exciter units, one steam-turbine driven and the other driven by a three-phase 250-volt induction motor.

The turbines are a modification of the usual two-stage type adapted to operate noncondensing. The casing is retained and the second stage removed. With nozzles proportioned differently for the new work, results much better than are ordinarily expected of a noncondensing turbine have been obtained. The rate guaranteed for 200 lb. initial pressure and atmospheric exhaust was 31.6 lb. per kw.-hr Under full load at the plant, the turbines have bettered this rate. At 200 lb. initial pressure, 1 lb. back pressure and 30 deg. of superheat, they have developed a kilowatt-hour on 31.2 lb. of steam. The consumption was measured by a General Electric recording flow meter which has been provided for testing purposes and for use on the live-steam line to the Railway Exchange Building.

A 6-in. lead from the superheating coils of each boiler runs 8 ft. horizontally to a tee reducing on the run to 5 in. to supply the turbine and discharging upward through the leg of the tee to a 6-in. header immediately above. A valve at each opening of the tee makes it possible for each boiler to supply a turbine directly or through the header either of the other turbines. A 5-in. supply pipe gives 0.026 sq.in. per kw. of rating and a 16-in. exhaust opening directly into a 24-in. main common to the other units gives 0.27 in. per kw. Fig. 6 shows the piping to and from the turbines.

The exhaust main supplies all the heating and is so valved that part of the exhaust of the main units, besides the exhaust from the auxiliaries, may be used in the feed-water heater or a hot-water heater for house service. Both heaters and the pumps are on a gallery above the turbines. In the Railway Exchange Building a Webster vacuum system is installed. Direct radiation is employed on the floors above the seventh and in the department store indirect radiation. The vacuum pumps, one steam-driven and the other motor-driven, are in the engine room. The smaller buildings served by the plant have gravity systems which put from 1 to 1½ lb. back pressure on the turbines. In addition, there is a 4-in. live-steam supply to the store for cooking and general restaurant purposes. This service is metered by a special General Electric indicating, integrating and recording instrument. At night high-pressure steam is supplied through a reducing pressure valve to the exhaust line for heating the building, as much as 30,000 lb. per hour being required in the colder weather.

Refrigeration is furnished to the store by two 50-ton Ruemmeli-Dawley compressors connected to 75-hp. motors by chain drives. The machines and the double-pipe ammonia condenser shown in Fig. 5 are in the plant, but the balance of the equipment is in the basement of the store. The liquid ammonia from the condenser and the returning vapor are therefore transmitted underground. The store is equipped with the brine system to tide over periods of nonoperation.

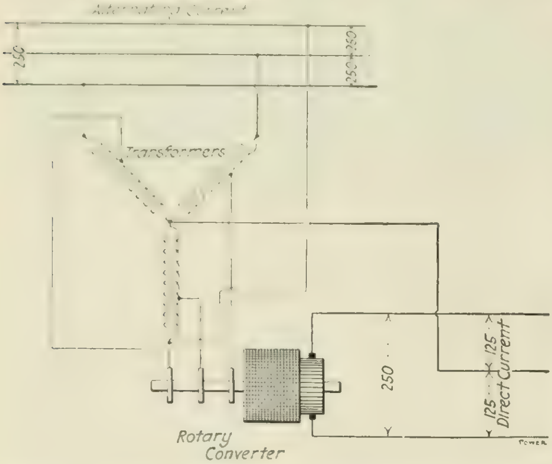


FIG. 12. FROM THREE-PHASE ALTERNATING TO DIRECT CURRENT AT 250 AND 125 VOLTS

In the Railway Exchange Building there are a total of approximately 12,800 tungsten lights of 100 cp. each, supplied with 125-volt alternating current. A number of three-phase motors require three-phase alternating current at 250 volts and 38 elevators use direct current at 250 volts.

From the generators the three-phase 60-cycle, 250-volt current is carried to the switchboard, 75 ft. distant through six 2,000,000 circ.mils lead-covered cables, two per phase. The leads have been placed in 3½-in. individual fiber ducts spaced on 4-in. centers, and to overcome the induction which would naturally result from the high-amperage current, the phase circuits have been divided. The grouping of the ducts is shown in Fig. 9, the corresponding numbers indicating the two leads of each phase.

All of the alternating-current power service is three-phase, 250-volt and is used direct. The lighting service is three-phase, four-wire, 125-216 volts. Fig. 10 shows how these voltages are derived. The supply is brought to a three-phase autotransformer with the coils connected in star. Taps are brought out from each coil and between each of the taps and neutral, the voltage is 125. Across the phases on the service end the voltage is 216. The latter voltage might be used for power service. To balance the load between the phases, the lighting circuits in the Railway Exchange Building have been taken off as shown in Fig. 11.

Direct current at 250 volts is required for the elevator motors and 125-volt current for lighting outside of the Railway Exchange Building. This service is derived from the supply through autotransformers and rotary converters, three 300-kw. units being installed. As shown in Fig. 12, taps from the transformer coils lead to the rings of the rotary and 250-volt direct current is delivered from the other end. The neutral of each transformer is brought out and between it and either of the direct-current leads there is a difference of potential of 125 volts.

The plant has an emergency service connection with the Laclede Power Co., which is made through two 1000-kw. banks of transformers with star-connected primaries and secondaries arranged in delta. The voltage is stepped down from 4150 to 250 volts. This service is also used during the summer months, as the current is bought as cheaply as it could be produced in the plant without the benefits accruing from the heating load.

PLANT RECORDS

Daily reports are kept of the steam, coal and water consumption and meters on the various services record the electrical output. Table 2, a report for the month of February, will give some indication of what the plant is doing. The figure of 11.9 lb. of coal per kw.-hr. does not give a fair indication of the economy of the plant, as a considerable portion of the steam generated by the coal was used for heating and for operating boiler-feed and vacuum pumps and the ash-handling system. Separating these items from the total by means of detailed reports obtained in the plant reduces the coal per kilowatt-hour to approximately 7 lb. For a noncondensing plant using dirty coal of scarcely 10,000 B.t.u., the latter figure is not bad. The coal costs about 90c. per ton, and at a rate of 7 lb., this would give a fuel cost of 0.31c. per kilowatt-hr. It will be noticed that the ratio of kilowatt-hours sold to kilowatt-hours generated is 87 per cent. This difference of 13 per cent. is due to the rotary and transformer losses and to the use of nearly 20,000 kw.-hr. in the plant. There are only 6375 kw.-hr. unaccounted for in the month's operation.

TABLE 2. PLANT RECORDS FOR FEBRUARY

Kw.-hr. generated	365,600
Kw.-hr. sold, d. c.	167,761
Kw.-hr. sold, a. c.	149,615
Kw.-hr. sold, total	317,376
Ratio kw.-hr. sold to kw.-hr. generated, per cent	87
Kw.-hr. to rotary converters, a. c.	190,070
Rotary and transformer loss, kw.-hr	22,309
Ratio of rotary d. c. to rotary a. c., per cent	88.3
Kw.-hr. used in plant	19,540
Kw.-hr. unaccounted for	6,375
Live steam to store for restaurant service, lb	285,355
Coal, lb	4,343,470
Ashes hauled, lb	995,000
Water, cu.ft	15,100
Coal for all purposes per kw.-hr. generated, lb	11.9
Coal per kw.-hr. electrical load, estimated, lb	7
B.t.u. per lb. of coal	6500 to 10,000
Make-up water, per kw.-hr., lb	2.7

Hugo Wurdack is president of the company, E. S. Billings is superintendent, and H. R. Mason is chief engineer of the plant. To Mr. Billings, we are indebted for much of the information contained in this article.

Purchasing Boilers--II

By J. E. Terman

SYNOPSIS—How to calculate the size of tubes and the layout. Design of boiler shell, and bracing, how the boiler is to be installed and how to designate what trimmings are to be used.

*

The size of tube to be used to best advantage is hard to determine as there are many factors to be considered. Generally speaking, the longer the boiler the larger the tube that can be economically used. Three, 3½- and 4-in. tubes have become standard for horizontal-tubular boilers in this country, and all other sizes can be said to be exceptions. Boilers with large tubes or flues, say 6-in. or more in diameter, are often capable of greater evaporating capacity per square foot of heating surface than boilers using smaller tubes, but this gain in capacity is usually at the expense of efficiency. The two-flue boiler could not be excelled for its ability to carry an overload, but it was hard on the coal pile.

A large tube is advantageous where the fuel used causes much soot, which rapidly fouls the heating surfaces. Small tubes require a more intense draft than large ones, and this is a point to be considered in selecting a boiler for a plant already having a chimney.

The tube sheets, or heads, should be made of fire-box steel with a tensile strength of from 50,000 to 65,000 lb. per sq.in. and the tube holes should be punched not less than ½ in. smaller than the finished hole and then reamed to size, or, better still, drill the tube holes in the solid plate.

Layout of Tubes

The tubes should not be too closely spaced for there is likely to be trouble from weakness of the bridges between the tube holes, the boiler will not steam freely, and there will also be difficulty in removing scale from between the tubes, especially next to the heads. The tubes should be spaced at least 1 in. apart, and should be arranged in straight vertical lines to permit cleaning and free liberation of steam. There should be sufficient height between the top of the tubes and the shell to allow of easy liberation of the steam so that it can be drawn from the boiler without carrying an undue amount of moisture with it.

As a large boiler liberates more steam per square foot of liberating surface, it requires a greater height above the tubes than would a small boiler. A boiler of, say, 48-in. in diameter should have a space of at least 18 in. between the top of the tubes and the shell; a 78-in. boiler should have about 27 to 30 in. The heights above the tubes for intermediate sizes should be in proportion.

To make a free-steaming boiler and one readily cleaned, there should be plenty of room between the tubes and the bottom of the shell and also at the side between the tubes and the shell, with a generous vertical aisle up the middle of the boiler between the tubes. While this aisle is generally made 2 in. wide, 3 in. is better. The tubes should not be placed nearer than 3 in. to the shell at the sides, and since the tube rows are straight and the shell curved, the average space will be considerably more than this.

Ample space at the sides affords proper facilities for cleaning as well as for circulation, and the importance of space at this point cannot be too strongly emphasized. The tubes should be beaded against the head on both ends; this is especially important on the rear head.

Bracing

The bracing of horizontal-tubular boilers is simple. That to be placed on the heads above the tubes is preferably of the solid, crow-foot type and made weldless, although good welded braces are safe when allowed the customary limit of 7500 lb. per sq.in. of net area as a maximum working load.

Gusset bracing is strong, but it is likely to become fouled with mud, which lodges between the gusset plates and makes proper inspection of the head impossible.

Through bracing should be avoided above the boiler tubes, since it interferes with their accessibility and may give trouble by loosening, particularly if the braces are of relatively small diameter. Below the tubes the through type of brace should be used, since it avoids the necessity of attaching brace pads to the shell where they are liable to cause trouble by overheating the shell plate immediately under the pads. The rear ends of through braces, below the tubes, should be pinned to crow-feet or pinned between angle irons riveted to the head.

Where angle irons are used, they should be arranged with a pipe washer 1 to 1½ in. long; placed over each rivet and between the angle iron and the head, to hold the angle iron away from the head, thus permitting the free circulation of water back of the angle iron. The front ends of the through rods should pass through the front head, using a nut on each side of the head and a cupped washer between the outer nut and the head of boiler for making a tight joint.

Boiler Shell

The shell of the boiler should be made of material of suitable thickness for the pressure desired; the minimum should be $\frac{5}{16}$ in. up to 54 in. sheet diameter and ⅜ in. thick above this size. The maximum thickness should not be over ⅝ in., and ½ in. or $\frac{9}{16}$ in. where scale is liable to become troublesome.

The seams should be of the butted and strapped type and either triple or quadruple riveted; for small boilers double riveting may be used. The rivet holes should be punched ¼ in. less than the finished hole and reamed to size after the straps and sheets are bolted in place, or the rivet holes can be drilled from the solid plate.

The ends of the plate forming the longitudinal seams should be pressed to the true circle of the boiler shell before the sheet is rolled. This is a feature that should always be specified. The butt straps should be formed to the true contour of the shell before the rivet holes are reamed or drilled. The girth seams should be single riveted and the different courses of the boiler properly fitted together, so that light calking is required to make the seams tight.

Heavy calking on the seams of a boiler should warrant its rejection, because it is a certain indication that the parts were not properly fitted together, and the result is trouble and a short life if the boiler is to be subjected to hard service. The shell should be constructed of firebox steel with a tensile strength of between 50,000 and 56,000 lb. per sq.in., material of a higher strength is liable to be less ductile and not as well suited for boiler purposes.

All brackets, nozzles or lugs should preferably be of pressed steel as should the manhole reinforcement. It should be required that these parts be properly fitted to the shell before being riveted on. There should be a manhole in the front head below the tubes (except for small boilers) and a manhole above the tubes. That above the tubes is preferably placed in the top of the shell, but it may be in the rear head above the tubes if the surrounding conditions make that the most suitable place.

The courses of a boiler should not be much over 8 ft. long, but they should always be so arranged that a girth seam does not come over the bridgewall; in fact, a girth seam that is nearer than 18 in. of either side of the bridgewall is likely to give trouble, due to overheating of the plate.

SUPPORTS

The usual practice is to support a horizontal-tubular boiler on side lugs, resting on the brickwork. This is the cheapest arrangement yet devised for that purpose and it gives fairly satisfactory results, but if boilers are hung from I-beams, which are supported on columns independently of the brickwork, the installation is much improved and the life of the setting as well as the safety of the boiler are enhanced.

Hanging the boiler from beams which are supported on piers built on top of the setting walls is an improvement over the lug-supported boiler. Between $18 and $25 usually covers the additional expense for hanging a boiler in this way, instead of supporting it on side lugs.

FRONTS

The front of a boiler is largely used to present a good appearance and to furnish a suitable means for attaching fire and ashpit door frames, which could not be attached to the brickwork as are the frames of the cleanout door.

Since the front usually furnishes a finished appearance to the setting, it should be designed to please the eye. The sectional plate-steel front is superior to cast-iron in appearance and is more serviceable in every way. Two fire-door openings are preferable for use on all except small boilers, say, under 48-in. diameter, but no door opening should be less than 16 to 18 in. wide and 15 in. high, so as not to interfere with the firing.

If a boiler is set with the overhanging type of front, which is the best type in many respects, it should be so designed that the boiler will be a sufficient height above the floor level to prevent the smoke-box extension from interfering with the fireman. It should be specified whether the fire-door arches and side pieces are to be furnished with the boiler and a description of the kind should be supplied by the bidder.

The fire and ashpit doors and frames should be of cast iron and made of sufficient depth and weight to prevent warping. A warped or cracked fire-door is not only unsightly, it is uneconomical. The cleanout door of the combustion chamber should have a clear opening of at least 18x18 in., and should be well fitted to the frame to prevent air leakage.

To plane or mill the edge of a door and its frame costs money, but unless they do fit, there will be a constant loss in efficiency during the operating life of the boiler. The cleanout doors and frames, like the fire-doors, should be designed with proper depth and weight to prevent warping. Bars or rods should be supplied by the boiler manufacturer to serve as lintels to hold up the brickwork over the cleanout door openings.

GRATES, ARCHES, ETC.

The principal requirement for grates is to have the manufacturer specify the area to be furnished and the weight per square foot of grate surface. The amount of grate surface should be such that there is 1 sq.ft. to each 40 or 45 sq.ft. of boiler heating surface. About 40 per cent. of the grate surface should consist of air spaces (grate manufacturers usually claim about 50 per cent.), but measurements will show such claims to be unwarranted, because it is not practical to make a substantial or serviceable grate with that much air space.

The covering arches for the rear of the combustion chamber should be designed to rest against the boiler head and on the rear wall. Such arches are more durable. They also follow the movements of the boiler while expanding and contracting, thus aiding in keeping a tight connection to prevent air leakage at the back end of the boiler.

TRIMMINGS

If real competition is desired in obtaining bids for boilers, there must be a distinct understanding as to the kind and quality of the trimmings to be furnished. The usual trimmings that are considered to be a part of the boiler contract are the steam gage, with the necessary connecting pipe and shutoff cock, safety valve, water column, water-gage glass and gage cocks, together with the piping between the water column and the boiler; the blowdown valve for the water column and the valves, if they are used, between the water column and the boiler.

Usually, chain pulls are provided for the water-gage valves, if these are of a type that can be arranged to operate from the floor. The boiler blowoff valve or cock is also usually furnished, and usually the piping to attach it to the boiler.

The steam gage should be of sufficient size to permit its indications being readily observed from the boiler-room floor, and an 8- or 10-in. face is a proper size. The maximum graduation of the gage should be at least 50 per cent. above the intended working pressure in order to secure accuracy and long life, and to permit a hydrostatic test of the standard amount being recorded. The pipe connecting the steam gage to the boiler should be of brass and not less than ¼ in. in size. Iron pipe is likely to clog with rust scale.

The pipe connecting the steam gage to the boiler should be formed into a goose-neck, unless the location of the gage is such that water will always be on the gage spring without the introduction of such a device. If steam is kept in contact with the gage spring, the indications are inaccurate, and the spring will be ruined. Similarly, heat transmitted from outside the gage is detrimental and the location should be such that it is exposed only to the normal room temperatures. The front of the breeching or upper portion of the boiler front is a poor location for the gage, unless it is insulated from the heat given off by these parts. The make and style as well as the size of a gage should be specified.

The safety valve should be of the spring-loaded type and the size should be specified as well as the make and style. If there are no laws to govern the size of the safety valve to be specified, all needs for safety will be complied with by calling for 1 sq.in. of safety-valve area for every 2 sq.ft. of grate area or each 100 sq.ft. of heating surface. There is a difference in price in safety valves, of about $25 on a 125-hp. boiler, so it is important that all bidders be on the same footing in this particular.

The water column is often made by the boiler manufacturer. If it is of good design, it can be accepted with his bid, but it is best to determine beforehand the kind of gage-cocks and water gages to be used. Then specify them, rather than try to differentiate between the kinds that will be offered by the manufacturers in submitting bids.

The piping between the water column and the boiler should not be less than 1¼ in. in size and crosses or tees should be specified in place of ells at points which will permit cleaning these connections by the removal of plugs in the unused outlets.

The pipe between the lower end of the water column and the boiler should be of brass as an aid in keeping the connections free.

The blowoff valve should be specified by the purchaser both as to size and style, since a considerable difference in price can be made by its use. The size of the blowoff should not exceed 2½ in., or be less than 2 in. for the horizontal-tubular boiler. It is practically impossible to give advice as to the style of blowoff valve to be specified, because there are so many types on the market which possess points of merit. It is best for the purchaser to choose one type so that all bidders will estimate on the one kind.

SPECIFICATIONS

While it is not practical for the average purchaser to write his own specifications, he can, in asking bids from manufacturers, request them to incorporate in their specifications the various features desired that are touched upon here, and the specifications which he will receive with the bids should be practically uniform.

If the purchaser desires to secure maximum efficiency in purchasing equipment, and is insured in a steam-boiler-insurance company, he can secure the desired specifications from it, and also the services of an inspector to watch the construction of his boilers, to see that the contract is properly carried out. These services are usually furnished free by the insurance companies.

The purchaser should bear in mind that in buying boilers, as in the purchase of other equipment, it is always best to deal with manufacturers who can be depended upon to stand back of their goods, even at a reasonable advance in price over the other fellow.

* *

Dampers for Water-Tube Boilers*

By Osborn Monnett†

SYNOPSIS—Some radical improvements in damper design and arrangement which have added to the efficiency of water-tube boilers.

*

The damper, breeching and stack for a water-tube boiler should be designed to offer the least possible resistance to the gases. A damper ratio of 1 to 4, expressed in terms of grate surface, has given good satisfaction. As in horizontal return-tubular practice, this ratio is better obtained by approximating a square cross-section rather than by making the damper long and narrow. It is important that the damper obstructs the uptake as little as possible when standing open.

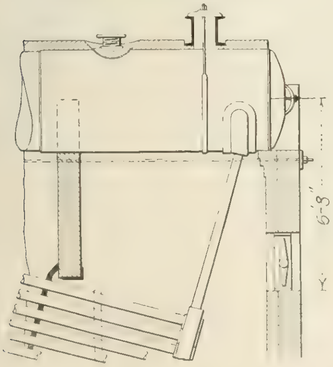


Fig. 1. Standard Rear-Wall Damper for Horizontal Water-Tube Boilers

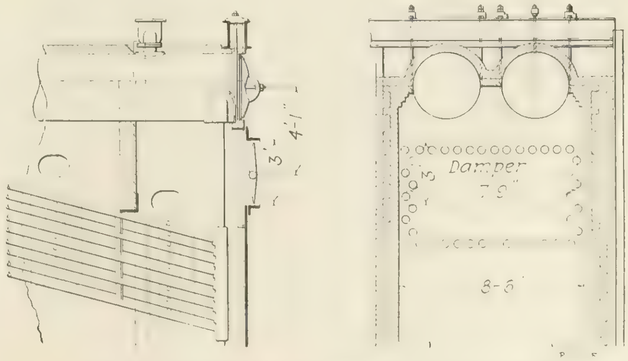


Fig. 2. Rear-Wall Damper of Later and Better Design

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*Copyright, 1914, by Osborn Monnett.
†Smoke Inspector, City of Chicago.

Characteristics of some of the different types of damper will be discussed. These types will be found to cover the ordinary makes of boiler on the market and can be modified to suit any installation with little or no change in general design.

REAR-WALL DAMPER

In the past this damper has been too small for high capacities. Fig. 1, an example of the older type, shows a damper much too small. This damper as usually installed does not extend the full width of the setting. Better results are obtained with the damper shown in Fig. 2, which extends across the boiler setting. There is less restriction to the gases and the capacity of the boiler is increased. In settings of this type the damper in any case should be made the full width of the setting as the circulating nipples restrict the available opening of the damper.

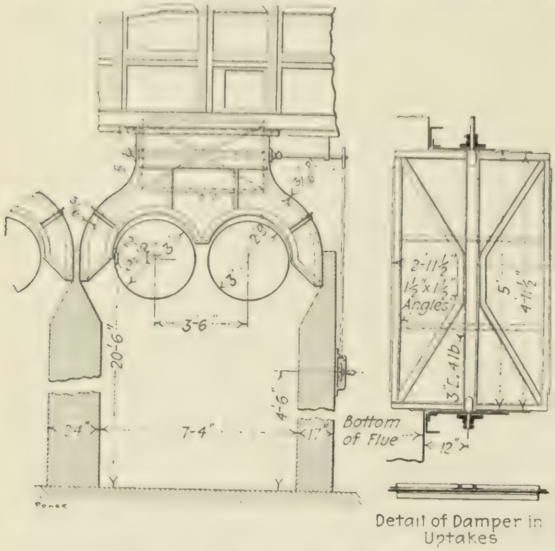

FIG. 3. DAMPER IN UPTAKE

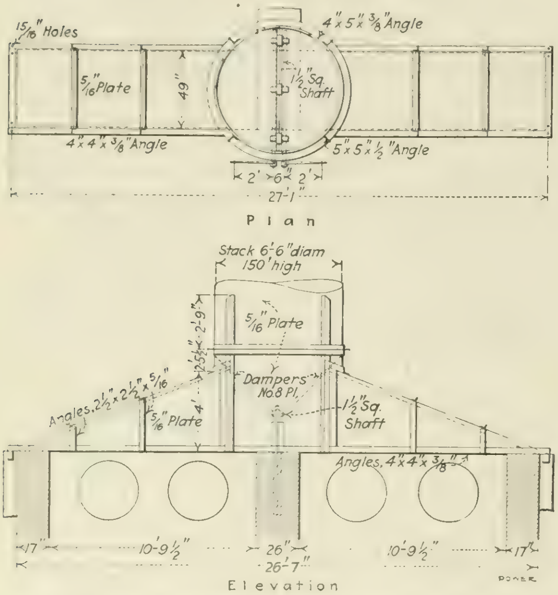

FIG. 4. IDEAL DAMPER ARRANGEMENT FOR TWO 500-HP. BOILERS

DAMPER IN TOP CONNECTION

This is the ideal damper connection for a horizontal water-tube boiler. In Figs. 3 and 4 working drawings of dampers of this type are given showing how they may be installed with a minimum resistance to the flow of gases. In this type of damper care must be taken not to unduly restrict the space between the side walls and the drum. To avoid this the side walls are corbelled out, as shown in Fig. 3. The damper may be installed at this point or in the uptake above the boiler.

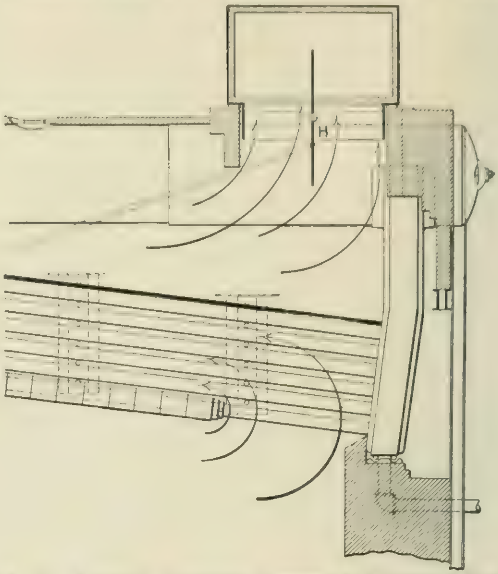

FIG. 5. FAULTY DAMPER LAYOUT FOR SINGLE-PASS BOILERS

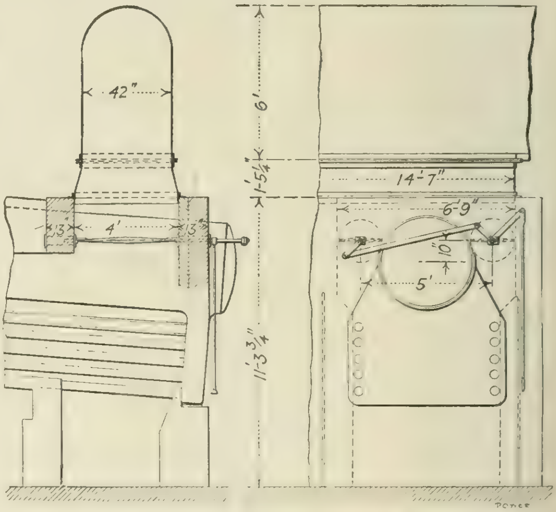

FIG. 6. LOCATION OF DAMPERS FOR HEINE TYPE BOILERS

The style of damper shown in Fig. 5 is faulty, as at best it interposes an obstruction to the flow of gases. Even with the damper wide open there is a neutral point at *H* which cuts off the effective area of the opening. Again, damper connections are not always tight and any lost motion in the joints or at the adjusting lever will cause the damper to hang out of center and restrict the uptake. This damper, then, should be avoided and the type shown in Fig. 6 substituted. Fig. 7 is a working drawing of the damper for a 350-hp. boiler. The dimensions can be varied to suit the size of boiler, using the same relative proportions and making the free opening one-fourth of the connected grate surface. The layout shown in Fig. 6 can be applied to any horizontal water-tube boiler. It permits a straight, uninterrupted flow of the gases into the stack.

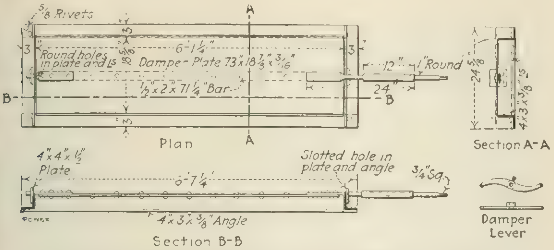

FIG. 7. DAMPER DETAIL FOR 350-HP. BOILER

STIRLING DAMPERS

The construction of this damper is necessarily long and narrow, and the space allotted to it is sometimes greatly restricted. The Stirling damper should be made as wide as possible. There are two types: The damper in the back wall, and the damper with top connection. One good and one bad installation of each type are shown in Figs. 8 to 11, with the third-pass baffle lowered to correspond with the ideas previously expressed. The best type of Stirling damper is that which provides the uptake on top with the wall corbelled out to give a maximum free opening.

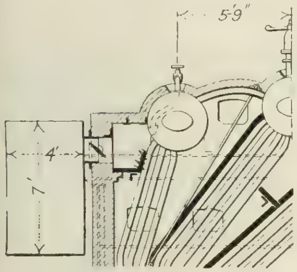

FIG. 8. POOR

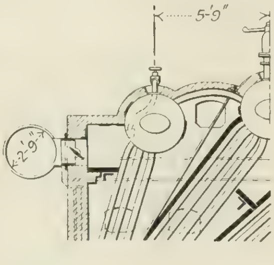

FIG. 9. GOOD

REAR-WALL CONNECTION FOR STIRLING BOILERS

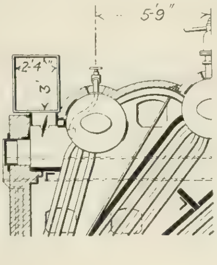

FIG. 10. POOR

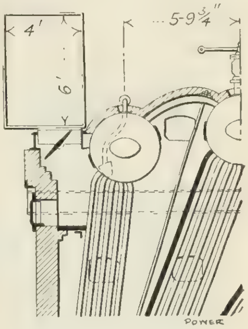

FIG. 11. GOOD

TOP CONNECTION FOR STIRLING BOILERS

DAMPER REGULATORS

When discussed strictly from the smoke standpoint, with high volatile Western coals, the average damper regulator is a trouble maker. On hand-fired installations it is practically impossible to use a damper regulator in territories where strict smoke ordinances are enforced. The damper may close without warning just after a heavy fire has been thrown into the furnace. Under these conditions the fire will smoulder and smoke before the fireman has become aware that the demand for steam has slackened.

On mechanically stoked plants the same trouble is likely to arise, although by careful attention to details, damper regulators have been installed with a fair degree of success. These have been arranged so that the stoker engine is slowed down as the steam goes up, before the damper is checked. Conversely, the damper opens before the stoker engine is again speeded up. No damper regulator should be installed under any circumstances with mechanical stokers, unless the above provisions are carried out.

⁂

Simple Method of Determining Hardness of Water

By W. H. Geare

According to statistics, most defects in steam boilers are due to scale and deposits, thus showing the importance of knowing the amount of scale-producing salts in feed water. To detect individual impurities in water is a rather troublesome job and as scale is caused by two or three chief impurities, the following is a good way for an engineer, with the aid of inexpensive apparatus, to estimate the amount of these scale-producing substances. Some scale forms when hard water is heated and is due to deposits of calcium and magnesium carbonates and calcium and magnesium sulphates. The former arise from temporary and the latter from permanent hardness.

In the first case, the salts are in solution as bicarbonates, which on boiling, lose the carbonic-acid gas and are converted into normal crystalline carbonates which are precipitated, the particles sticking to the side, forming scale. In the latter case, the salts are in solution as sulphates. These are not affected by boiling and the scale in this instance is formed simply by evaporation.

The total hardness is the amount due to both the temporary and permanent.

Both temporary and permanent hardness may be tried for, and the result will give the amount of impurities causing scale. A standard is adopted as "degrees of hardness" and is expressed as grains per gallon or parts by weight in 100,000.

The apparatus required consists of: 1 burette, 100 cu. cm. (c.c.) reading to tenths c.c.; 2 glass-stoppered bottles, 200 c.c. capacity; 1 flask, 500 c.c. capacity; 2 pipettes, 70 c.c. and 100 c.c. To estimate the impurities, secure the total hardness as follows: Get from any manufacturing chemist a standard soap solution. It is of such strength that 1 c.c. will neutralize 1 mg. or 0.001 gram of calcium carbonate (one solution that can be used is 15 grams of castile soap dissolved in 500 c.c. of alcohol and 500 c.c. of pure distilled water). Take a sample of the water and put 70 c.c. into each bottle. Now run from the burette containing soap solution a few cubic centimeters (say two or three at a time) into one of the bottles, shake it vigorously and lay on its side. If a lather does not appear, add more soap solution little by little until a slight lather appears on the surface of the water. At this stage, the soap solution should be added, two or three drops at a time. Allow the bottle to lie on its side for four minutes. If the lather breaks before the end of that time, add a little more solution, shaking the contents vigorously after each addition. When the lather stands or lasts for four minutes the test is done. The use of two bottles is to save time; while one is standing, the other can be in use, i.e., the soap solution may be added and shaken.

To calculate: 1 c.c. of soap solution equals 0.001 gram of calcium carbonate. Assume 70 c.c. of the sample were taken and say it required 8 c.c. of solution to produce the lather. Therefore, there are 8 grains of carbonates per gallon of water, which is 8 deg. of total hardness. If 100 c.c. of sample water had been taken then we would have had 0.008 gram per 100 grams of water (1 c.c. of water weighs 1 gram) or 8 parts per 100,000, also 8 deg. The total hardness of water expressed in degrees is as follows: 4 to 5 deg. is soft; 10 to 12 deg. is hard; 15 to 16 deg. is very hard.

To determine the permanent hardness due to the sulphates, simply boil the sample for half an hour (this will destroy the temporary hardness); then repeat the test, taking 70 c.c. or 100 c.c. as before.

If more than 16 c.c. of solution are required to produce the lather, then dilute it to half its strength with pure distilled water, but be careful to double the result obtained. If very large quantities of calcium or magnesium salts are present, this method is not strictly correct, but is good for comparing different waters.

To get the amount of suspended matter causing sediment, simply filter 70 c.c. of sample water through a filter paper and weigh before and after; the weight in milligrams equals grains per gallon.

To find if the water is acid, hold a piece of red and blue litmus paper in the water for one-half hour. If acid is present, the blue will turn red and the red remain red; if it is alkaline the red will turn blue and the blue remain blue.

Though this cannot be considered strictly an analysis of water, it is, however, a practical method of obtaining the general quality for boiler purposes. For comparing various waters, and in a plant where a water-softening process is used, it will prove very useful.

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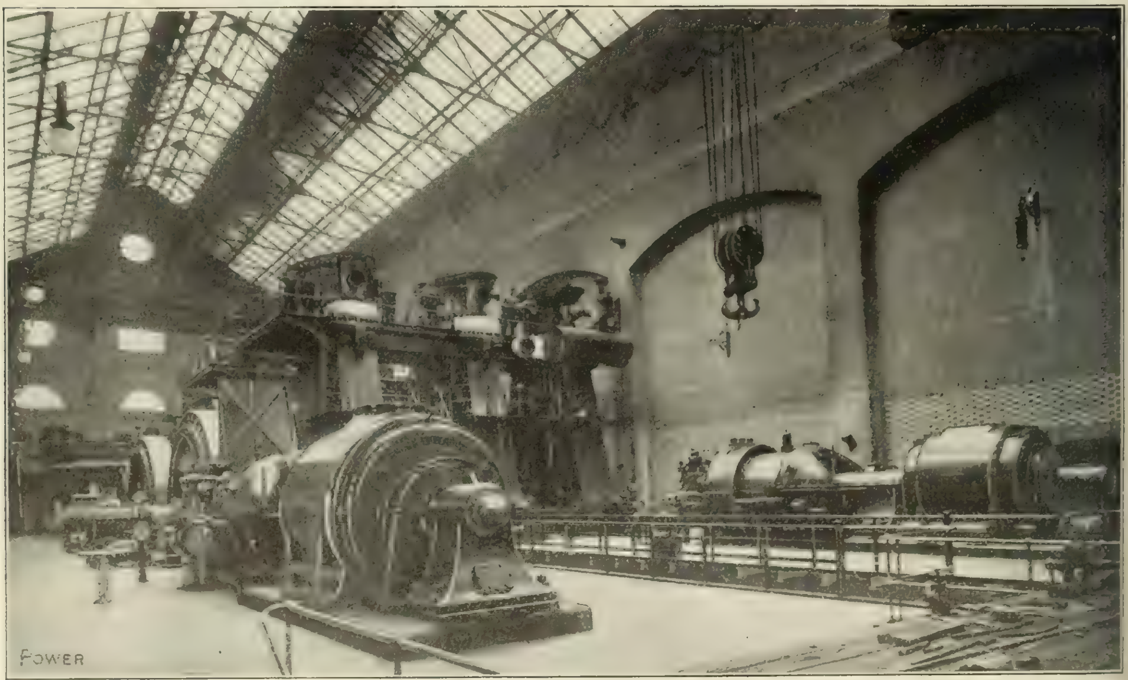
Signs of the Times



The Two Turbines in the Foreground Have a Capacity Equal to That of the Whole Roomful of Engines, of Which That Just Behind the Turbines Is Shown Being Dismantled

From Central Station to Consumer

By F. McNeill

SYNOPSIS—A study in British thermal units of central-station service to a large isolated plant which has boilers for heating of more than sufficient capacity to generate the electrical load. A generating plant, it is estimated, would save about $40,000 per year.

* * *

The central-station and isolated-plant argument has reached a point where it behooves every engineer to give it unbiased consideration. If the central station can compete with the isolated plant successfully, the operating engineer should be the first to make the discovery, thereby deriving any benefits possible of the inevitable result of such a discovery. On the other hand, if it can be shown to the contrary, then such findings should be given all the publicity possible in order to offset some of the statements or misstatements, as would then be the case, that are now freely circulated by the central-station interests.

For instance, the central-station advocate has comparatively easy sailing when he is able to approach a prospective customer with the following statement, which is more misleading because it is half the truth, "We have as a customer one of the largest retail department stores in the city of Chicago who find it more profitable to deal with us than to operate their own plant." It is a fact that that there is such a store in Chicago and that it does buy its power from the central station, but by what intricate reasoning the management of that store arrives at the conclusion that it is saving money by so doing is beyond the writer's ability to discover.

The electrical power consumption at that store will run anywhere from 300,000 to 400,000 kw.-hr. per month. It has an elaborate boiler plant of 2100 hp. capacity, and is equipped with a refrigeration system of the absorption type.

It has been suggested that one of the reasons why this store does not operate its own generating plant is because the owners are interested in the concern furnishing them with power and light, so they virtually use their own product, and at the same time advertise their central station. This may or may not be true.

The engineers employed by the central station are fully aware of every loss, however slight, from the coal bin to the consumer. They must, therefore, be aware that the actual cost of production of heat, light, power and refrigeration is considerably greater than it would be were that power generated in the basement of the store.

Central stations throughout the country have been accused of fostering by rate discrimination just such propositions as the foregoing. How well the scheme works as an advertisement is shown by the large number of stores and office buildings that use central-station power. It is not possible for the managements to prove to themselves or to anyone that they are practicing economy; hence the only logical conclusion is that they are consumers of central-station power on account of rate discrimination, the misleading statements of the central-station solicitor, or they are victims of the class of advertising circulated by the average purveyor of electrical energy.

It is safe to say that the managers of the particular store under discussion would not have to think twice, in the event that central-station power was not available, before deciding that the place for their power plant would be in the basement of their store and not four or five miles distant, as is the case now. They would not have to employ consulting engineers to tell them that the apparatus for transmission and conversion of the power would cost almost, if not quite, as much as the proper machinery installed in their basement. It is quite probable that they would not install engines of the condensing type with all the auxiliary apparatus that would be necessary in order to get a high thermal efficiency, which would not exceed 15 per cent. at best. Engines of the single-expansion or possibly compound type, utilizing the exhaust for heating, refrigeration and ice making, would give good economy if the supply and demand for exhaust steam were anywhere near balanced.

That the enormous waste this one case represents in money as well as fuel may be better understood and appreciated, and that the reader may see the foregoing statements proved, the actual work being done will be converted into its equivalent heat value in British thermal units. A comparison will be made of the heat units expended under present conditions with the possibilities were the the engines and generators in the store.

One kilowatt-hour is equivalent to 3412 B.t.u. Assuming that the kilowatt-hour consumption per month is 300,000, the total useful work done would be equal to

$$300{,}000 \times 3412 = 1{,}023{,}600{,}000 \ B.t.u.$$

The central station in this case is equipped with the most efficient steam and electric-generating apparatus procurable. Boilers, however, are not discriminatory; they will do just as efficient work for an isolated plant as they will for a central station. For these comparisons an efficiency of 70 per cent. will be assumed in each case.

The prime movers in the central station are turbines operated condensing, and some of them are extremely large, with a test rate as low as 11.25 lb. per kw.-hr., not including the auxiliaries. Due to low load factors and standby losses, the average economy does not approach this figure. It is commonly stated that to produce a kilowatt-hour at the switchboard requires 30,000 B.t.u. Only 70 per cent. of this reaches the turbine, so that with steam at 200 lb. pressure and 200 deg. superheat, the average rate per kilowatt-hour would be

$$\frac{0.7 \times 30{,}000}{1309.7} = 16 \ lb. of\ steam$$

As the turbines and accessories use 16 lb. of this steam per kilowatt-hour, the heat units required for 1 kw.-hr. of output is

$$16 \times 1309.7 = 20{,}955 \ B.t.u.$$

and as 1 kw.-hr. is equal to 3412 B.t.u., the thermal efficiency would be

$$\frac{3412}{20{,}955} = 16.3 \ per\ cent.$$

The next loss sustained is that of the generator, which may be assumed in both cases to be 5 per cent. The transmission loss is next; this is sustained by the central station alone. It is governed by the cost of copper and its installation. The question of installation cost in this case is so complex that a conservative estimate is rendered difficult. The wires are laid in expensive ducts, and many thousands of kilowatts are conducted over the same wires which are divided into a multitude of smaller circuits. It should be borne in mind, however, that the item is not small. The writer has been informed on good authority that the transmission loss allowed is 10 per cent., but to be on the safe side, a loss of 8 per cent. will be assumed. It does not matter how much power is transmitted over the lines, copper has to be provided for every ampere that flows. That is, there is no saving in copper on account of the large amount of power being transmitted. The same amount of copper is required to convey that power to the store as would be necessary were it the only current flowing.

The distance the current is transmitted is about four miles. It is transmitted at 9000 volts, three-phase, three-wire distribution, and is converted into direct current at a usable voltage by means of a rotary converter which, by the way, is not 100 per cent. efficient. A well designed converter of 1000 kw. capacity would have an efficiency of about 95 per cent. at full load. The current required to supply 1000 kw. at the end of the line, assuming the average power factor to be 0.90, would be

$$\frac{1,000,000}{9000 \times 1.732 \times 0.90} = 71 \textit{ amp. per main}$$

Assume that the power has a value at the end of the line of 1.5c. per kw.-hr. A transmission loss of 8 per cent. on 1000 kw. is 80 kw., and if that loss were sustained 10 hr. a day for 52 weeks of six days each, it would amount to 249,600 kw.-hr., which at 1.5c. would amount to $3744. This money would pay the interest and depreciation at the rate of 12½ per cent. on an investment of $29,952, which in itself would help materially in building a respectable isolated plant.

The size of conductor required would be No. 4, and the cost of 12 miles of this wire, making allowances for the fact that larger conductors are used, would be about $7000. These figures are derived from a quotation by a Chicago dealer. When the cost of the rotary converter is added to this amount, together with the maintenance cost, a sum of from $30,000 to $35,000 is represented. Adding to this the amount represented by the transmission loss would give a sum sufficient to install a generating plant which could compete successfully with any central station in operation today.

When one stops to think that this may be accomplished with the central station's waste, or at least with the losses that are an inseparable part of the central station but foreign to the isolated plant, one of the reasons why the former cannot long endure as a successful competitor to the latter is apparent.

For heating, about 160,000 sq.ft. of radiating surface is required. Under average conditions 100 sq.ft. of radiating surface will require one boiler horsepower, so that an installation of

$$\frac{160,000}{100} = 1600 \textit{ hp.}$$

would be necessary. On the assumption of full boiler capacity for 14 hr. a day and seven months during the year the annual coal consumption would figure out about 10,000 tons. Information emanating from a reliable source, however, gives 7250 tons as the average yearly consumption for heating the building, so that the latter figure will be used for final comparisons.

An expense borne by the isolated plant and not by the central station is the cartage cost of coal from the cars to the plant. Whatever that item is, the reader must remember that the coal now used for heating alone bears that expense, so the only difference is the cartage cost of the difference between the coal now used for heating and the amount that would be used for power and heating, which would be small.

With an isolated plant the boiler and generator efficiencies would be practically the same as those of the central station, so that it is only necessary to consider the engines. It is probable that two 800-hp., nonreleasing, four-valve engines would be selected for the work. A guarantee per indicated horsepower-hour of 22 lb. of saturated steam at 140 lb. absolute and 1 lb. back pressure can be obtained, although in practice the rate would be nearer 25 lb. The thermal efficiency of the engines in this case will differ from that of the turbines in that the turbines dissipate all of the heat energy in the steam delivered to them, for which they return 16.3 per cent. in the form of electrical energy, while the reciprocating machine of the isolated plant uses only a small part of the heat in the steam passing through it, rejecting the greater part as exhaust. The exhaust steam, however, has a thermal value of 100 per cent. for heating, ice making, etc.

Saturated steam at 140 lb. absolute has 1192.2 B.t.u. per lb. Between this pressure and 1 lb. gage, or, say, 16 lb. absolute, the engine will utilize only 158 B.t.u.; that is, this amount will be transformed into work. There will also be about 5 per cent. cylinder condensation, which will mean another drop of 60 B.t.u., or a total of 218 B.t.u. In every pound of steam the engine uses 218 B.t.u. and the balance, 974 B.t.u., is turned over to the heating or refrigerating systems.

As the engine uses 25 lb. of steam per indicated horsepower-hour, it requires

$$25 \times 218 = 5450 \textit{ B.t.u.}$$

for each indicated horsepower. To drive a 500-kw. generator of 95 per cent. efficiency, and allowing for 10 per cent. friction in the engine the latter would have to furnish

$$\frac{500}{0.90 \times 0.95 \times 0.746} = 783 \textit{ i.hp.}$$

In doing so it would use.

$$783 \times 5450 = 4,267,350 \textit{ B.t.u. per hr.}$$

The heat equivalent of 1 kw.-hr. is 3412 B.t.u. Therefore,

$$3412 \times 500 = 1,706,000 \textit{ B.t.u.}$$

is equivalent to the total useful work of the generator. Then considering that the exhaust is utilized, the thermal efficiency of the set would be

$$\frac{1,706,000}{4,267,350} = 0.399$$

or practically 40 per cent. It will be remembered that the thermal efficiency of the central-station unit, figured in the same way, was 16.3 per cent.

As there are two engines in use, each developing 783 i.hp. for 25 lb. of steam per i.hp.-hr., and 974 B.t.u. are rejected per pound of steam, then the boiler horsepower represented by the heat rejected by the engines is

$$\frac{2 \times 783 \times 25 \times 974}{33,479} = 1139$$

It will be remembered that a maximum of 1600 b.hp. is required for heating the building, so that all of this exhaust could be utilized for the greater part of the heating season; in other words, the total waste would be all of the exhaust steam five months of the year. No matter how much of the exhaust steam cannot be used, it is always available if required—that is, there is the equivalent of 1139 boiler horsepower of exhaust steam always ready for use wherever the 1600 boiler horsepower is now being used.

Assuming for the time being that all of the exhaust steam escapes to the atmosphere, the total heat used by the engines per hour would be

$$1192.2 \times 1566 \times 25 = 46,674,630 \ B.t.u.$$

During that hour the generators are supplying 1000 kw., which is equivalent to 3,412,000 B.t.u. The thermal efficiency of the units would then be

$$\frac{3,412,000}{46,674,630} = 0.073 = 7.3 \ per \ cent.$$

To the critic who will say that too much steam has been allowed for heating, the writer wishes to call attention to the fact that this particular store is equipped with a refrigeration system of the absorption type which could use not a little of the exhaust steam, and the large restaurant maintained by this store uses steam the year round.

The accompanying table compiled from the data given in this article shows the difference in heat units between the two methods. Considering everything, the writer believes that if any advantages are given, the central station is most favored.

Comparison between Central-Station and Isolated-Plant Service

CENTRAL STATION FURNISHING POWER

Apportionment of work	Heat Value in B.t.u.
300,000 kw.-hr. per mo.	1,023,600,000
5 per cent. converter loss	53,873,684
8 per cent. transmission loss	93,693,363
83.7 per cent engine and generator loss	6,013,906,866
30 per cent. boiler loss	3,079,317,392
7250 tons of coal used per yr. for heat	10,264,391,305
Average per mo.	13,288,000,000
Total	23,552,391,305

ISOLATED PLANT FURNISHING POWER

Apportionment of work	Heat Value in B.t.u.
300,000 kw.-hr. per mo.	1,023,600,000
92.7 per cent. engine and generator loss	12,998,317,808
30 per cent. boiler loss	6,009,393,346
Average heat per mo. in addition to exhaust furnished	289,682,192
Total	20,320,993,346
Excess heat expended account of using central station power	3,231,397,959
Equivalent in tons of coal saved per mo. (11,000 b.t.u. per lb.)	147
Tons of coal saved per year	1764

The table shows the saving in coal between the two methods, but not the saving that might be effected by installing an electric plant in the store. The item of profit to the central station must be considered.

According to a schedule issued by the central station in question, the store has to pay 1.54c. per kw.-hr. for a maximum of 1000 kw. when the total amount used is 300,000 kw.-hr. per month. The monthly cost for power at that rate would be $4620. By referring to the table it will be seen that the total heat expended per month for heat, light and power by the isolated plant would be 20,320,993,346 B.t.u., and it now expends 13,288,000,000 B.t.u. for heat alone, a difference of 7,032,993,346 B.t.u., which represents 320 tons of coal.

It is the writer's candid opinion that no additional help would be required in this case with the possible exception of one fireman during the summer months. Allowing for this for six months at the rate of $80 per month, which would make an average of $40 per month for the year and 320 tons of coal at $2 per ton, the total additional cost would be $680 per month for power and light, for which the store now pays $4620, a difference of $3940. For 12 months this would amount to approximately $47,000, allowing for oil and supplies for the engines. The annual saving would very nearly install the generating units. The plant woould almost pay for itself in the first year, and deducting 12½ per cent. on the investment for interest and depreciation, would still leave an annual saving of about $40,000.

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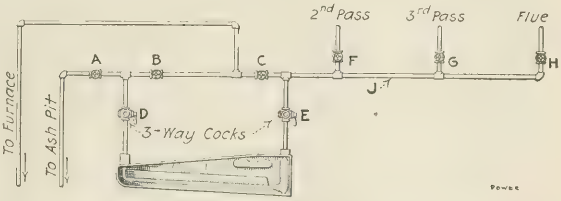
Draft-Gage Piping

By D. McGregor

[This article was published in the Apr. 14 issue, page 539, but the draft gage was shown connected wrong end to. That there may be no misunderstanding regarding the method of taking readings, the article is republished herewith with the gage properly connected.—Editor.]



Piping and Valves for Draft-Gage Connections

The illustration shows how a boiler may be piped up to a differential-draft gage so as to give any desired reading. It is adaptable either to forced- or to natural-draft conditions, and requires some ¼-in. pipe and fittings, six straightway and two three-way cocks; the latter can be made out of regular cocks by drilling a small hole through the side of the cock and half way through the plug when set open.

Following is a list of the readings that may be had and how they are taken, supposing that all of the cocks are closed except those mentioned in each case:

1. For ashpit pressure, open *AD* straightway and *E* to the atmosphere.
2. For furnace pressure, open *BD* straightway and *E* to the atmosphere.
3. For furnace suction, open *CE* straightway and *D* to the atmosphere.
4. For drop through the fuel bed, open *A* and *C*, also *D* and *E* straightway.
5. For drop from ashpit to second pass, open *A* and *F*, also *D* and *E* straightway.
6. For drop from ashpit to third pass, open *A* and *G*, also *D* and *E* straightway.
7. For total available draft from ashpit to flue, open *A* and *H*, with *D* and *E* straightway.

8. For drop through boiler from furnace to second pass, open B and F, also D and E straightway.

9. For drop through boiler from furnace to third pass, open B and G, with D and E straightway.

10. For drop from furnace to flue, open B and H, with D and E straightway.

11. For draft at second pass, open D to atmosphere, E straightway and F.

12. For draft at third pass, open D to atmosphere, E straightway and G.

13. For draft in flue, open D to atmosphere, E straightway and H.

* * *

De Launty Gasoline Engine

For a number of years, O. M. De Launty, of Chicago, has been perfecting a two-cycle engine for automobile, marine and small power use in which crank-case suction and compression is replaced by a positive feed for the fuel, secured by the introduction of storage chambers and an enlargement of the engine piston at the lower end to form a pump for forcing the mixture to the combustion chamber.

The general arrangement of the engine is shown in the illustrations. Fig. 1 represents a four-cylinder engine of this type, and Fig. 2 represents diagrammatically a plan of two cylinders and the corresponding storage chambers. The engine is made up of two-cylinder units, which, as in the present case, may be duplicated if desired. The cranks are set 180 deg. apart so that when one cylinder is on the working stroke, the other is receiving and compressing the charge. As will be apparent in Fig. 1, the engine and pump pistons are concentric, and as both are one casting, they act in unison. The capacity of the pump is the volume contained between the engine piston and the cylinder walls of the pump when the combination piston is at the bottom of the stroke. Each pump serves the opposing cylinder.

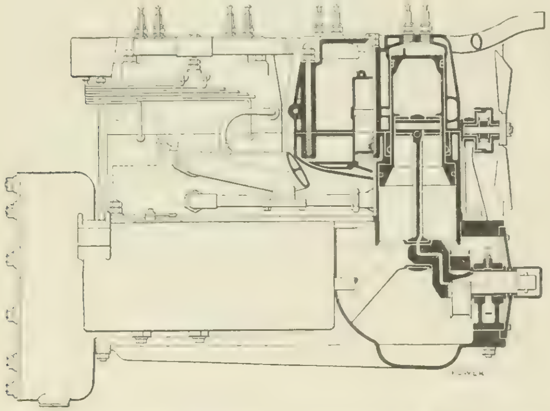


Fig. 1. Section through Cylinder of De Launty Gasoline Engine

The cycle of operation may be traced in Fig. 2. The charge for cylinder A_4 is drawn from the carburetor through the inlet A_1 by the pump A_2 of the opposing cylinder. On the upstroke of this pump it is forced into the storage chamber A_3 and when the engine piston of A_4 uncovers the ports the charge flows into the cylinder, pushing ahead of it the burned gases through the exhaust A_5. Between the pump A_2 and the storage chamber A_3 there is a ball check valve, and a second one between the storage chamber and the cylinder. The cycle of operation for the other cylinder is the same, as indicated by the subfigures for B.

The pump capacity is about 10 per cent. greater than that of the engine cylinder and the volume of the storage chamber is about 20 per cent. less. The chamber is large enough to receive the charge from the pump up to the point of admission of the opposing cylinder and store it at 4 lb. pressure. As admission occurs before the end of the stroke, the pump is still acting and forces a full charge into the cylinder. This is compressed to about 75 lb. in the engine cylinder.

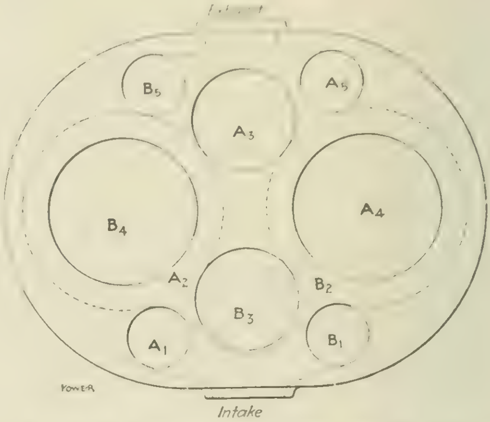


Fig. 2. Plan Showing Arrangement of Cylinder and Storage Chambers

In Fig. 1 it will be noticed that the engine piston has two rings, the pump piston one, and in the cylinder walls between the ports and the pump cylinder there is another. The ring last referred to is pushed inward by oil pressure to prevent any suction toward the pump cylinder and at the same time to lubricate the piston. The rubbing surface is greater than in the usual design, but the benefits secured from a full charge at each stroke should more than overbalance the excess in friction.

The maker is the De Launty Engine Co., 407 South Aberdeen St., Chicago, Ill.

* * *

Air-Tank Regulations—The Massachusetts Board of Boiler Rules has issued regulations to carry into effect a legislative act relative to the construction and inspection of tanks containing compressed air for use in operating pneumatic machinery. Tanks exceeding 18 in. in diameter and sustaining a pressure of more than 50 lb. per sq.in. must be inspected at least once in every two years by a state inspector, unless the tanks are inspected and insured by an authorized insurance company. The regulations cover the size, shape, construction, operation, maximum pressure and safety devices of such tanks.

Calculating Radiation for Steam and Hot-Water Heating

By Charles L. Hubbard

The square feet of direct radiation for a given room or building are found by dividing the total heat loss by transmission and leakage per hour, in B.t.u., by the efficiency of the type of radiator used. This simply allows for maintaining the normal temperature after the room is warmed. When the building is allowed to cool off at night, from 10 to 15 per cent. additional radiation should be provided, for quick warming in the morning.

Experience has shown that but little, if any, more fuel is required for warming a building continuously than when it is allowed to cool down at night. Although no heat is taken from the boiler when the radiation is shut off, the building and its contents are constantly giving out stored heat which must be replaced by forcing the plant before the rooms can again be raised to their normal temperature.

For this reason, the heat in large buildings is kept on for a part of the night, at least, to prevent the temperature from falling greatly. In cases of this kind it is not common to allow any additional capacity for "warming up," especially as the radiating surface is proportioned for the coldest weather and is, therefore, in excess of the requirements for most of the time. Furthermore, the lower temperature of the building adds to the efficiency of the radiation, thus increasing the power of the plant still more under these conditions.

Efficiency of Direct Radiation

The efficiency of a radiator depends upon the difference in temperature between the inclosed steam or water and the surrounding air, and also upon the velocity of the air passing over the heating surface. For the average conditions of direct heating the following rates of transmission may be used for different types of radiation. The variation is due to the form of surface, which affects the freedom of air flow as noted.

TABLE I.

Type of Radiation	B.t.u. given off per hr. per sq.ft. of surface per deg. difference in temperature between the radiator and surrounding air
Four-column radiators, 38 in. to 45 in. high	1.5
Three-column radiators, 38 in. to 45 in. high	1.6
Two-column radiators, 38 to 45 in. high	1.7
Three- and four-column radiators, 18 in. to 26 in. high	1.7
Wall radiators	1.8
Wall coils, 1 in. to 2 in. pipe	1.9

Assuming the temperature of the surrounding air as 70 deg., "working efficiencies" may be used for steam and water, as given in Tables 2 and 3 respectively.

TABLE 2. (STEAM)

Type of Direct Radiating Surface	B.t.u. given off per sq.ft. of surface per hr.	
	2 Lb. Gage Pressure	Atmospheric Pressure
Two-column radiators, 38 in. high	255	240
Wall radiators	270	255
Pipe coils	285	270

TABLE 3. (WATER)

Type of Direct Radiating Surface	B.t.u. given off per sq.ft. of surface per hr. for different average temperatures of water		
	170 deg.	180 deg.	200 deg.
Two-column radiators, 38 in. high	170	185	220
Wall radiators	180	200	235
Pipe coils	190	210	245

As a matter of fact, in computing the radiating surface for a system to be used in connection with a power plant, practically no difference is made in the amount furnished, whether for low-pressure gravity, vacuum steam, or forced hot water, although the efficiencies for the usual conditions are given in the tables as 255, 240 and 220 B.t.u. respectively.

While it is common to carry 2 to 5 lb. pressure in gravity plants using live steam, it is desirable in exhaust heating to reduce this to a point as low as is consistent with a proper discharge of air and of condensation against atmospheric pressure. As air venting and steam circulation are somewhat more positive with a vacuum system, the radiator efficiencies in each case are practically the same, although the pressure and the corresponding temperature is slightly less in the latter case.

Hot water, circulated at an average temperature of 200 deg., with a drop not exceeding 20 deg. (210 deg. to 190 deg.) will have an actual efficiency approximately equal to that of steam at atmospheric pressure, although the theoretical efficiency is somewhat less. This is due principally to the high velocity of the water flowing through the radiators, together with the entire freedom from air. When a live-steam heater is provided, initial water temperatures considerably higher may be employed if desired. In the earlier systems of forced hot-water heating, lower temperatures were carried, thus requiring larger radiators than for steam. Under the conditions of modern practice, efficiencies corresponding to those given for steam at atmospheric pressure in Table 2 may be used for all three classes of direct heating in connection with power work.

When a cast-iron radiator is concealed by grille work, the surface should be increased 25 per cent. and the openings so arranged that the air will circulate freely over it. Coils hung near the ceiling should be increased in size about 30 per cent. where it is desired to maintain a comfortable temperature near the floor.

Efficiency of Indirect Radiation

If it is simply desired to warm a room by indirect radiation, without reference to ventilation, the direct radiating surface may be computed and the result multiplied by 1.5. When definite conditions as to air temperature and volume are required, the following formulas may be used.

$$C = \frac{L \times 55}{(T - t)}$$

$$T = \frac{L \times 55}{C} + t$$

$$H = \frac{T \times C}{55}$$

in which

C = Cubic feet of air required per hour, at temperature T, to bring in the necessary heat (L) to warm the room;

L = Heat loss from the room, in B.t.u. per hour, due to transmission and leakage;

T = Required temperature of air supply (C) to warm the room to 70 deg.;

H = Heat required, in B.t.u. per hour, to raise the air supply (C) from outside temperature to that of admission (T);

t = Room temperature, commonly taken as 70 deg.

Example—The total heat loss from a room by transmission in zero weather is 30,000 B.t.u. per hour. The cubic content of the room is 12,000 ft., and it is desired to change the air four times per hour. What volume of air must be supplied, and at what temperature must it be admitted to warm the room to 70 deg.? What amount of indirect radiating surface will be required?

With indirect heating the loss due to *leakage* in buildings of first-class construction may be omitted when computing the total heat loss. The entering air, in this case, is warmed before it reaches the room, and the heat required for this purpose is included in that to be furnished by the indirect stack. When the building is poorly constructed, so that there is considerable inward leakage of cold air around the doors and windows, the heat loss by transmission should be multiplied by 1.1 to 1.2, according to local conditions.

Applying the preceding formulas to the present case, we have

$$C = 12{,}000 \times 4 = 48{,}000 \textit{ cu.ft. per hr.}$$

$$T = \frac{30{,}000 \times 55}{48{,}000} + 70 = 104 \textit{ deg.}$$

$$H = \frac{104 \times 48{,}000}{55} = 91{,}000 \textit{ B.t.u. in round numbers}$$

Having determined the value of H, the square feet of indirect radiation required to warm the room may be found by the equation

$$R = \frac{H}{E}$$

in which

R = Square feet of radiation;

E = Efficiency of radiator employed.

The value of E depends upon the temperature of the radiator, the average temperature of the air passing over it, and the velocity of flow.

With a velocity of 270 ft. per min., about 2.1 B.t.u. will be given off by the radiator per square foot of surface per hour, per degree difference between the *average* temperature of the air and that of the radiator. The average air temperature in the present case is

$$\frac{0 + 104}{2} = 52 \textit{ deg.}$$

Therefore, if steam at atmospheric pressure is used (212 deg.), the efficiency E will be

$$(212 - 52) \times 2.1 = 336 \textit{ B.t.u.}$$

For other velocities the efficiency will vary and may be computed by use of Table 4.

TABLE 4.

Velocity of air over heating surface, in ft. per min.	B.t.u. given off per hr. per sq. ft. of surface per deg. difference in temperature between the radiator and surrounding air.
150	1.54
200	1 82
250	2 02
300	2 22
350	2 42
400	2 60
450	2 72
500	2 81

EFFICIENCY OF INDUCTION HEATERS

Heaters of this type are often used in laundries, loft buildings, etc., where discharge ventilation is produced by means of a fan and the air supply is drawn in through heaters, due to the suction effect of the exhaust.

The conditions here are much the same as already described for indirect radiation, except that the velocity of the entering air is usually somewhat greater than in the case of gravity work, which increases the efficiency slightly. In the case of direct-indirect radiators of standard type, an efficiency of 2 B.t.u. per square foot of surface per hour per degree difference between the radiator and the average air temperature may be assumed, while with pin radiation and similar patterns, which break up the air currents more thoroughly, an efficiency of 2.3 B.t.u. may be used.

Example—A room 20 and 40 by 15 ft. has a heat loss, due to transmission, of 20,000 B.t.u. per hour in zero weather. Exhaust ventilation is to provide eight air changes per hour. What will be the required heating surface, in the form of direct-indirect radiators?

Applying the formulas as before,

$$C = 20 \times 40 \times 15 \times 8 = 96{,}009 \textit{ cu.ft. of air per hr.}$$

$$T = \frac{20{,}000 \times 55}{96{,}000} + 70 = 82 \textit{ deg.}$$

$$H = \frac{82 \times 96{,}000}{55} = 143{,}000+ \textit{ B.t.u.}$$

Average air temperature,

$$\frac{0 + 82}{2} = 41 \textit{ deg.}$$

Temperature of steam at atmospheric pressure, 220 deg.

$$E = (212 - 41) \times 2 = 342 \textit{ B.t.u.}$$

$$R = \frac{143{,}000}{342} = 418 \textit{ sq.ft. radiation}$$

In the case of laundries and loft buildings, the process is practically the same, except that direct radiation is commonly employed for heating and the induction stacks are used simply for ventilating purposes. In this case the required heat is determined directly by the formula

$$H = \frac{T \times C}{55}$$

in which T is commonly taken as 72 to 74 deg., unless a portion of the warming is also done by the induction heaters.

When ventilation only is required, an efficiency of

$$(212 - 31) \times 2.3 = 416 \textit{ B.t.u.}$$

per square foot of surface per hour may be allowed for pin radiation with steam at atmospheric pressure.

⁂

The British Coal Output—The British home office has issued an advance proof of the tables relating to the output of coal and other minerals in the United Kingdom during 1913. The output of coal, which was 260,398,578 tons in 1912, rose last year to 287,411,869 tons, the highest total on record. There were 1,127,890 persons employed at mines under the coal mines act, an increase of 38,800 on the previous year. The increase in the output of coal is 10.37 per cent., the increase in the number of persons employed is 3.56 per cent.

⁂

Correction: In the report of the lecture by Dr. William H. Walker, of the Massachusetts Institute of Technology, on "The Manufacture of Steel Pipe," on page 651 of the May 5 issue there is a misstatement. The sentence beginning on the last line of the first column should read "To produce one ton of iron in a blast furnace there are required approximately eight tons of air, two tons of ore, one ton of coke and one-half ton of limestone."

City Plant Started Up

After standing idle for nearly four years, or since its installation in 1910, the generating plant at Raymond Street jail, Brooklyn, was started May 13 in the presence of Commissioner Davis and several guests.

The plant is well laid out and consists principally of two 150-hp., B. & W. high-pressure boilers, one 100-kw. and one 75-kw., direct-current generators, each driven by a Harrisburg Fleming engine; a switchboard and the usual auxiliaries. At no time is the electrical load greater than the capacity of one generator, and when a blower has been provided, as is contemplated, one boiler should be able to carry the entire heating and electrical load, even in severe weather. Thus sufficient reserve capacity will be had and breakdown service will be unnecessary.

During the period that the plant was shut down the full operating force, consisting of a chief engineer, two assistants and three firemen, was retained. Therefore, the labor charges were going on just the same, as were also the investment charges, and it was necessary to have a boiler in service during the summer to provide steam for the kitchen, hot water for baths, etc.; yet the city paid the Brooklyn Edison Co. about 6c. per kilowatt-hour, while it could have produced its own electricity probably for ½c. per kilowatt-hour (exclusive of the items referred to, which went on anyway). While the exact amount paid out by the city for electricity during the time the plant was shut down is not readily obtainable, it is estimated that the city would have saved about $25,000 had it not shut down the plant.

Credit for starting the plant is due largely to C. G. Armstrong, consulting engineer for the city, Deputy Commissioner Lewis, and J. R. Coe, on behalf of the N. A. S. E.; also to Miss Davis, the Commissioner of Correction, whose insight into the economic aspect of the problem led her to take prompt action in the matter.

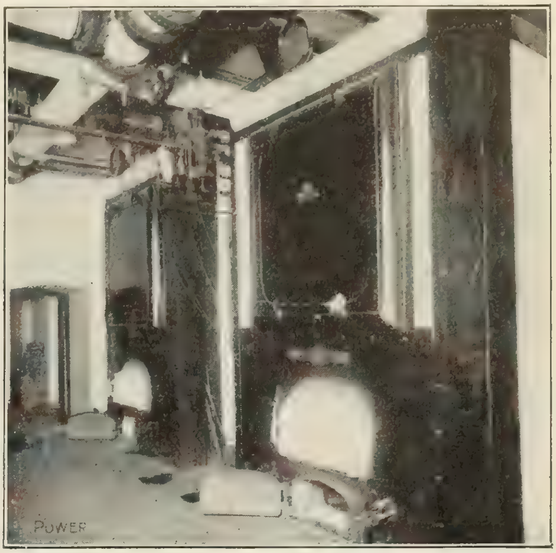


Fig. 2. Boiler Room

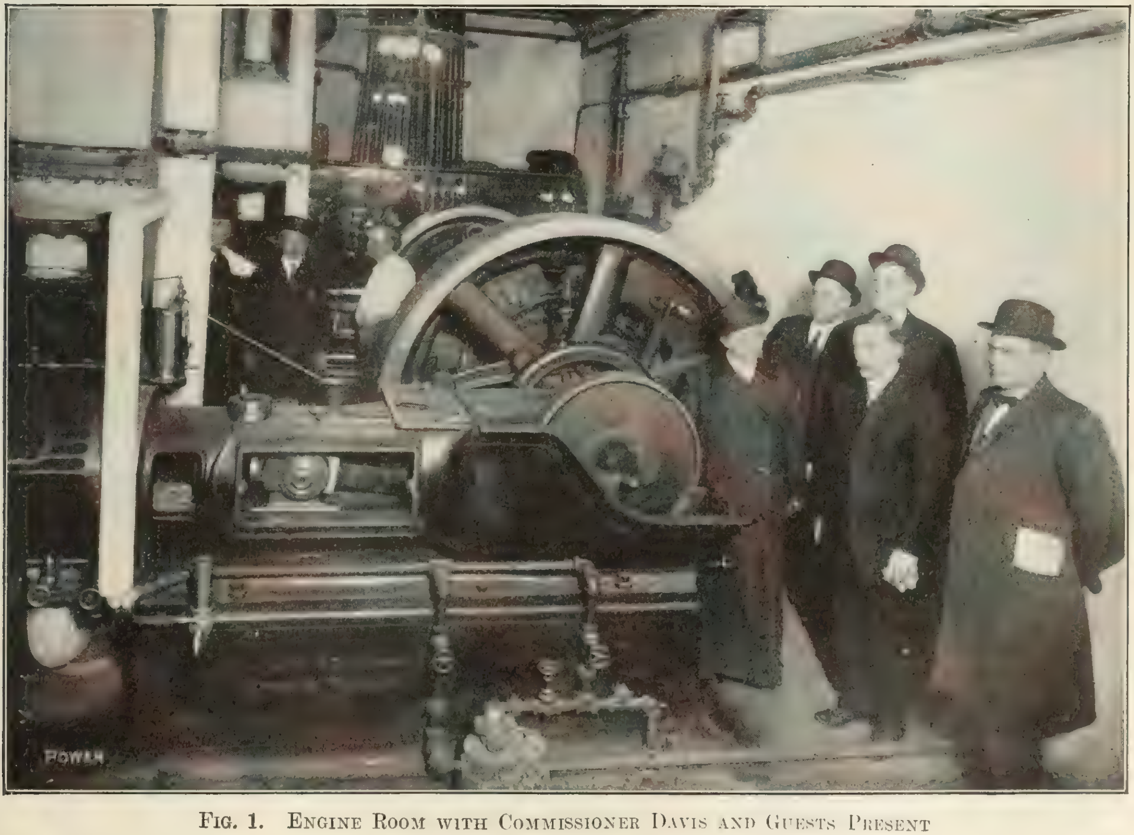


Fig. 1. Engine Room with Commissioner Davis and Guests Present

Hocking Valley Slack Coal

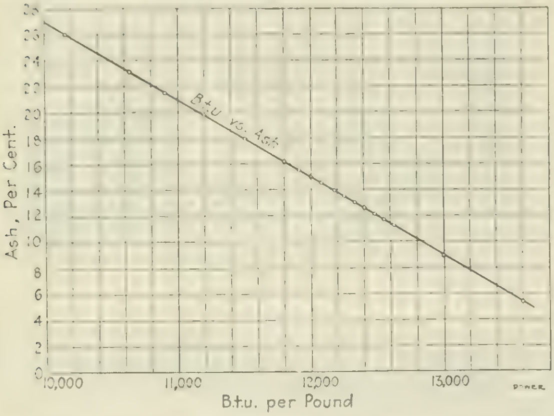
By Morgan B. Smith

SYNOPSIS—The relation which exists between heat value and ash content.

⁂

The writer has been aware for some time that there exists a definite relation between the heat value and the ash content of any given coal. This relation, when shown graphically by plotting the heat value vs. ash content, takes the form of a practically straight line, the ratio being inverse. The greater the heat value the lower the content of ash.

During the period June, 1, 1912, to Oct. 1, 1913, the writer had the supervision of the sampling and testing of Hocking Valley slack coal representing in all some 1800 separate samples, many of which were monthly average samples made up from the daily car receipts at several power stations. The results of these tests, when plotted in graphic form, show a remarkable agreement in the relation which the heat value bears to the ash content of this particular coal. In fact, this relation is so definite that a chart made up as shown may be used as a check on the actual calorimetric determination or on the amount of ash contained in any given sample. Thus if the ash is determined the heat value may be read off the chart within a maximum error of from 10 to 50 B.t.u. compared with the actual calorimetric value determined in the ordinary bomb calorimeter.



HEAT VALUE VS. ASH CONTENT OF HOCKING VALLEY SLACK COAL

The calorimeter used in these tests was the standard Atwater bomb apparatus. The bomb is gold lined with the exception of the lining of the top, which is of platinum. The thermometer used was a standard Bechmann differential, range 5.5 deg., furnished with the Deutsche Reichanstalt's certificate and also the certificate of the U. S. Bureau of Standards by whom it was checked. All samples were dried for one hour at 221 deg. F. in an electric oven before making the tests for heat value.

The ash determinations were made in a muffle furnace at a temperature of 1562 deg. F., the heating being continued until the samples came to a constant weight. No fluxing of the ash resulted in any of the samples with average sulphur content. Some samples in which the sulphur content reached a value of from 3.5 to 4 per cent showed fluxing in the furnace even at the moderate temperature employed, but these were very few.

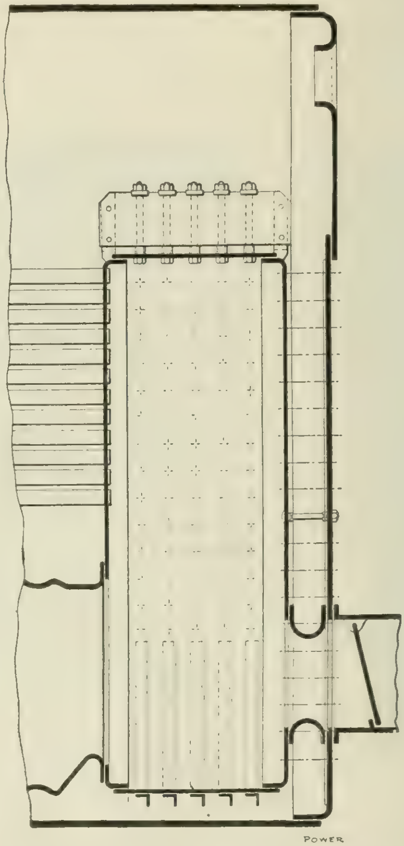
The coal received is said to have been received from some 20 different mines so that the samples tested over so long a period must be representative of the general run of the coal available under the name "Hocking Valley slack." The average proximate analysis is as follows:

Fixed carbon, per cent	52.[illegible]
Volatile, per cent	34.20
Ash, per cent	13.[illegible]
Av. sulphur, per cent	1.[illegible]
Av. heat value, B.t.u. per lb	12,[illegible]
Av. moisture in coal as received, per cent	9.85

The writer has found the chart valuable for check purposes and is submitting it with the thought that it should prove equally valuable to other consumers of this coal.

⁂

A Safety Suggestion



SUGGESTED OPENING IN BACK OF MARINE BOILER TO ALLOW ESCAPE OF STEAM IN CASE OF TUBE OR SHEET FAILURES. (SEE FIRST EDITORIAL)

Editorials

The Explosion Aboard the "Jefferson"

Added to the long list of the fatalities of the sea is the boiler explosion aboard the Old Dominion liner "Jefferson" off Cape Henry on the night of May 11, with its awful toll of eleven dead. This is a repetition of those grewsome accidents aboard the "St. Paul," "Delaware," "Bennington," "Sonoma," "Alamo," "Principe de Piedmonte" and many others.

Worse than rats in a trap, these unfortunates in the fifteen by forty-foot firing aisle, without warning, find themselves in the hold turned to hell by the escaping steam and water. There is no smooth floor to tread on, but instead, piles of coal and ashes and long, heavy firing-irons snare the feet.

The lights go out. Boiling water burns their feet and steam cooks their bodies. They cannot see, they cannot hear, and to rush too carelessly for the small doorway is to trip and fall into the scalding pool.

If steamships could not be run and commerce carried on without this kind of a sacrifice there would be nothing to do but to charge up so many more victims to the inevitable struggle, and let those who were sufficiently removed from the desolated homes and the wrenched heart strings forget it.

But the exigencies of marine engineering do not demand such a toll of human life. At some cost which "the traffic will bear" at some "inconvenience," less in the aggregate than that sustained by the victims and their dependents, conditions in the stokehole can be made such that a man need not commend his soul to God every time he goes on watch.

What is the reason that each boiler cannot be provided with inwardly or vertically opening furnace and ashpit doors and each combustion chamber have an opening into a substantial duct leading to the atmosphere above the water line? A damper made to stay shut normally by its own weight and the pressure difference between the sides, if placed in the duct at the boiler, would discharge most of the steam to the atmosphere in case of failure instead of blowing fire and steam into the boiler room. Sufficiently heavy plate used in the construction of the flue would provide a good outlet for steam, particularly if the front tube sheet should let go. The sketch on the opposite page shows diagrammatically the suggested plan. The arrangement, it seems, is applicable to most, if not all, boilers of this generally used type.

The "Jefferson," like nearly all vessels, was not provided with automatic nonreturn valves. True, due to the location of the boiler—near the only doorway exit—a few men might have been fatally scalded, even though such valves were provided, but in this case seven-eighths of the steam that filled the boiler and engine rooms never would have escaped if nonreturn valves had been used. That these valves are not more widely employed in marine practice is peculiar. They are generally reliable, and it is but rarely that one fails to operate when properly installed and maintained. Some modern vessels having water-tube boilers do use nonreturn valves, but one seldom finds them, and further, one cannot discover a good reason why they should not be used.

There is evidence that low water was the cause of the accident aboard the "Jefferson." The crown-sheet was sagged and the upper right-hand portion of the tube sheet was blown away from twenty-four tubes. The sheet was not badly burned, however, as the projected area was pushed back with a jack and new tubes were put in. The ends of the stay tubes were in good condition, the one from which the sheet blew entirely away was not distorted, and the hole in the sheet was perfect, except that it was enlarged just enough to allow the pressure—190 pounds, normally—to force it over the beaded tube end.

The ashes were being taken out at the time of the accident, and, on this ship, the pressure usually dropped thirty pounds when this work was being done.

Economy or Purchased Current?

On other pages of this issue an interesting estimate is made of the saving that would be effected if a large department store made its own current for power and lighting instead of buying it from a central station. The method of comparison is unusual, and perhaps some of our readers may not agree with the results obtained.

A discussion on the points of difference would be instructive and we will be glad to publish any legitimate comment from the central station, from Marshall Field's, which is the store in question, or from any of our readers who may have some knowledge of the plant. The question is too important to pass without comment. This particular store has been used time and again as an illustration of the efficiency of central-station service. If the service is saving the plant money, it would be interesting to know the amount, and at what rate the current is bought.

With the operating conditions stated in the article and the rate of 1.54 cents per kilowatt-hour, below which the central station cannot go without making itself liable for discrimination, it is a foregone conclusion that an uptodate generating plant would pay big returns. The boiler capacity already installed would be sufficient for the new conditions; the exhaust steam from the electrical load would supply the heating except for the few cold days in the winter when the temperature hovers around zero, and in average winter weather there should be exhaust steam to spare for the refrigerating plant and for the restaurant. The two services last mentioned would take a considerable portion of the exhaust steam during the summer months, so that a comparatively small amount would be wasted to atmosphere.

Conditions more favorable to an isolated plant do not often exist. Ordinarily, an isolated plant in which all the exhaust steam is used for heating will produce results which the central station cannot meet. With a refrigerating load in summer and a restaurant using some of the exhaust steam, the conditions are still better. With its low load factor and high fixed charges, the central station cannot lower the annual cost for the different services except at a heavy loss. At a rate of 1.51 cents per kilowatt-hour, it is certain that an isolated plant would effect a large saving and it would not be surprising if the annual gain reached the forty thousand dollars estimated in the article.

In the present case the coal can be received and the ashes removed through Chicago's underground freight tunnel, so that the argument based on dirt and annoyance usually advanced is void, and, for that matter, the plant is receiving nearly as much coal now as it would require with generating units in operation. The smoke nuisance should be no greater. It is indeed difficult to imagine any economic reason why the store should buy its current, but if there is an advantage, now is the time to give it publicity. It is hardly fair to continue using this store as an example favoring purchased current without stating the probable loss it is sustaining by not generating its own current. While engineers are not so easily deceived, building owners unfamiliar with technical matters might readily be influenced by the mere fact that a store of such magnitude was buying current. If they knew that this same store, possibly for personal reasons, such as are given in the article, was sacrificing every year a possible saving almost large enough to install an uptodate generating plant, they would think twice before following its example, if economy was preferred to central-station service.

An unbiased engineering analysis will surely point toward the isolated plant, and when the decision is made on this basis, there will be fewer buildings in Chicago and elsewhere in which the lighting and heating will be separated and the former bought at a considerable disadvantage.

End of a Culpable Practice in Sight

It seems to have become the accepted practice for New York City to install generating plants in its public buildings, then shut them down and purchase electricity. Notable instances are the City Prison (Tombs), the Williamsburg Bridge, Police Headquarters and the Raymond Street Jail, which has just been started again (see page 739). In the two latter instances, the generating plants had never been put in service, after their acceptance trials, yet the full operating force was retained in each case. The Williamsburg Bridge plant was taken out after having run for a short time.

If the load conditions in any of these cases were such as to make a generating plant unprofitable, one should never have been installed. Somebody blundered! Having installed a plant, however, with the investment and depreciation charges going on, as well as the labor, it is hard to conceive of conditions so bad as to render purchased current, at five or six cents per kilowatt-hour, cheaper than the cost of the additional steam and supplies for the generating units.

On the other hand, there are instances where the conditions are ideal for a generating plant and none has been installed. In this connection may be mentioned Bellevue Hospital (see Power, Jan. 20, 1914) which has a large heating plant, ventilating system and refrigerating outfit. Here there is a large demand for exhaust steam during the entire year, and the electrical load averages over 85,000 kilowatt-hours per month, yet there are no engines and generating units.

Such a state of affairs can be attributable only to gross incompetency or willful intent to defraud the city. We believe it to be the latter. While each commissioner is responsible for the plants in his own department, we understand that practically all these plants were shut down upon the recommendation of the Department of Water Supply, Gas and Electricity, whose close affiliation with the New York Edison Company is a matter of common knowledge. Perhaps the responsibilty does not stop there; it may extend "higher up."

This connivance between the New York Edison Company, on the one hand and certain city officials or "near officials" on the other has probably cost the city a sum running into five ciphers. Fortunately the end seems to be in sight. The recent step taken at the Raymond Street Jail is but an opening wedge; as soon as the necessary repairs have been made, the Tombs plant will follow, and it is to be hoped that Commissioner Woods will emulate the example set by Commissioner Davis and order the plant at Police Headquarters started.

A Lesson from Recent Explosions

By a peculiar coincidence, there are described in this and last week's issues of Power, two boiler explosions from similar causes at points remote from each other and of boilers of entirely different types. In each case the cause is attributed to a flaw or crack in the sheet and each flaw was so situated that it could not have been seen after the boiler was built.

In one instance it appears to have been a flaw in the original sheet, and not caused by rolling to shape in the boiler shop; by chance the sheet was located above the fire. The failure did not occur at a seam. In the other case it appears to be a combination of a brittle sheet and a severe forming strain. The failure occurred at the seam and the flaw was concealed by the strap.

The moral seems to be plain: More thorough inspection of plates during their manufacture.

*

An evidence of the growing tendency to put the rights of man ahead of the rights of property is seen in the following utterance of Gifford Pinchot in his campaign as a candidate for the Washington Party nomination for United States senator from Pennsylvania:

> If elected I will work for a law giving to a national commission the power to limit the wholesale price charged by the anthracite monopoly or its agents in interstate commerce. The price fixed should consist of a reasonable price for coal at the mine, sufficient to provide good wages for the miners, and a reasonable charge for transportation and handling. A reasonable profit should be included. The saving to the public should be applied in part to greater safety for miners, and in part to lowering the cost of living by reducing the price of coal. The monopoly in anthracite coal, which is a necessity of modern life, should be subject to the obligations of public service. This monopoly charges high prices because it has the power. That power must be destroyed.

Correspondence

Holman's New Blowing Engine

Some statements made about a new blowing engine in the Mar. 3 issue call for a few remarks: The combination of a rotary and a gridiron valve is not new. It was patented July 16, 1901, by Charles A. Bennett of Dover, N. J. The drawings attached to patent specifications No. 678,534 show almost the same identical arrangement as Holman's, as may be seen from Fig. 1, herewith, showing two views copied from the specification drawings.

Bennett's valves have been in use for a number of years on air compressors and blowing engines built by a Cincinnati concern. The only difference between the two designs seems to be that the gridiron valve in Bennett's device is actuated by air pressure, while Holman's valve is moved mechanically by a cam bar which resembles the cam motion that has been used for the last 15 years by the Southwark Foundry & Machine Co. to move the gridiron valves on its blowing engines. Holman's mechanism is rather complicated.

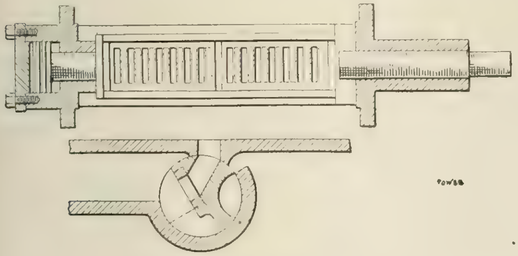


Fig. 1. Bennett's Air Valve

The statement that "the use of the flat gridiron and Corliss valves for compressors and blowing engines has not been attended with the best results on account of the difficulty in lubricating the inlet valves," cannot go unchallenged. There has never been the least difficulty in lubricating these valves; in fact, they seem to be more easily lubricated than any other part of the mechanism.

A few figures will show what the inlet valves will look like if the inlet area is to be made 25 per cent. of the cylinder area. Take, for instance, a 60-in. diameter blowing tub, the area of which is 2827 sq.in.; 25 per cent. of this is 707 sq.in., which divided by 2 gives 353.5 sq.in. inlet area for each valve. Assume that the ports are 60 in. long—which, of course, is hardly possible, since they cannot be located on the center line. Even so, the width of the ports would have to be about 6 in., requiring valves of at least 12-in. diameter. Imagine four such valves for an engine with a piston speed of 900 ft. per min. to move, say, 2 × 90 = 180 times a minute through an arc of about 80 deg. Consider the inertia of the moving parts. A valve-gear like that and running at the speed assumed would go to pieces in a short time. If the engine had a stroke of 54 in. instead of 60 in., as in the foregoing calculation, the number of revolutions would be increased from 90 to 100, and matters would become still worse.

Piston speeds of 800 or 1000 ft. per min. are not desirable for Corliss engines, gas engines, blowing engines, etc., if they are installed with a view to lasting and giving good service. Blast-furnace blowing engines, as a rule, are run night and day for long periods with a few stops a day for casting. It is, therefore, not advisable to run them at such excessively high speeds. It is doubtful if it pays to run reciprocating engines over 700 ft. per min., which should also be the limit for blowing engines. The first cost of an outfit running at higher speed is less than one running at moderate speed, but first cost should not be the only consideration, for wear and tear and efficiency must be taken into account.

Another erroneous idea in the article is that large Corliss valves can be made interchangeable and that one spare valve will be sufficient for an engine. Any shopman knows that it is impracticable, if not impossible, to bore four portholes of 10- or 12-in. diameter, 5 or 6 ft. long, exactly alike. Each valve must be fitted to its own porthole to be tight; besides, the wear of two valves or two portholes is never the same, so it would be of little use to keep one finished valve on hand.

American engineers have struggled for a number of years with indifferent success to design mechanically operated valve-gears for blowing tubs driven by gas and steam engines at high piston speeds. The blowing cylinder, in which the tub itself forms the inlet valve, as shown in Fig. 2, is an example. In this design the air is drawn in through openings in the cylinder shell. By this means an inlet area of 25 per cent. and over of the piston area can be attained, and the clearance in the inlet is reduced to zero. The objection to this valve-gear is the inertia of the blowing tub and the power absorbed in moving it back and forth. Take, for example, a 60-in. blowing cylinder with a stroke of 54 in. for 80 r.p.m. If the cylinder weighs 7000 lb. and the travel is 10 in., including the friction of the packing rings and the driving mechanism, it would probably require from 25 to 30 indicated horsepower to operate the valve-gear, or from 4 to 5 per cent. of the total.

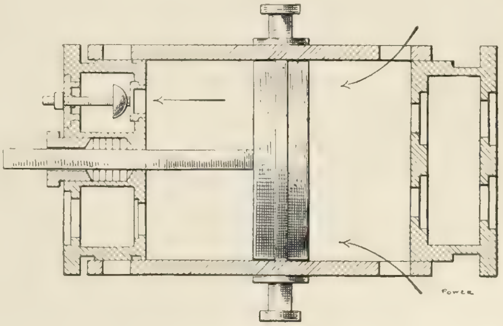


Fig. 2. Slick's Blowing Tub

European engineers who have been confronted with the problem of adapting blowing engines to high piston speeds for a longer time, due to the early development of gas-engine-driven units, have almost entirely discarded mechanically operated valves for plate valves, as shown in Fig. 3, where are shown designs by Hoerbiger, Ehrhardt & Sehmer, and by Borsig.

Valves of this kind do not require extra eccentrics and ponderous driving mechanism. They improve the mechanical efficiency of the engine and reduce the wear and tear and the cost of repairs. A blowing tub as usually made in Europe is shown in Fig. 4. The valves are placed opposite one another in the heads, concentric to the bore of the cylinder, giving a large area for the inlet and discharge openings. The clearance is increased, but this is not serious when we consider that the pressure seldom exceeds 15 lb. per sq.in. The volumetric efficiency is slightly reduced, but the loss in compressing and expanding the air in the clearance space is negligible. It is a curious fact that this design is almost identical with the blowing tub which Edwin Reynolds built over 20 years ago for some plants in the Middle West.

H. HAMKENS.

Newark, N. J.

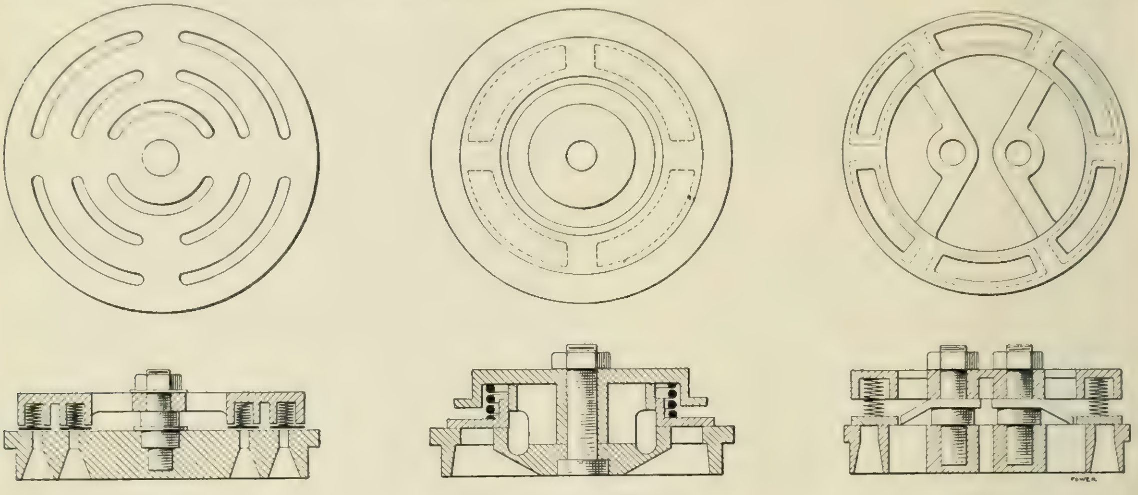

HOERBIGER EHRHARDT AND SEHMER BORSIG

FIG. 3. PLAN AND SECTIONAL VIEWS OF DIFFERENT TYPES OF VALVES

It was not claimed in the article under discussion that the combination of a rotary and gridiron-iron valve working together was new, nor that moving the gridiron valve with a cam bar was new. The combination of gridiron and rotary valves is covered by both Bennett's and Holman's patents. The application and arrangement of the rotary-gridiron valve is described whereby very large inlet areas, ease in removal and renewal of parts, efficient lubrication and positive mechanical movement of all the valves are obtained is, as far as I know, decidedly new.

In regard to Mr. Hamkens' statement that it is not difficult to properly lubricate inlet valves of the Corliss and gridiron type, I can only repeat that the difficulty does exist, and it is a very real one, as he may readily ascertain by investigating plants where large machines of such a type are operating. In the machine described the inlet valves are as easily lubricated as the main crosshead.

In order to relieve Mr. Hamkens' fear of Corliss valves, 12 in. in diameter and their inertia, I would refer him to any of the large engines in rolling mills and power plants where it is common to see Corliss exhaust valves much larger than 12 in. operating without any signs of distress after years of continuous and severe service. By large engines I mean 4000 hp. and over, operating at 80-85 r.p.m., a not unusual condition.

Piston speeds do not determine the life of the valve-gear; in fact, there is no relation between the two, and in modern plants a limit of 700 ft. per min. piston speed is not usual.

In first-class Corliss engine shops it is usual to bore the four valve ports in a cylinder alike, a variation in size being only due to bad machine work or bad casting, and it is not the custom when the work is done properly to file and fit the valves to the bore. The valves are turned and sometimes ground a few thousandths smaller than the bore and that is all.

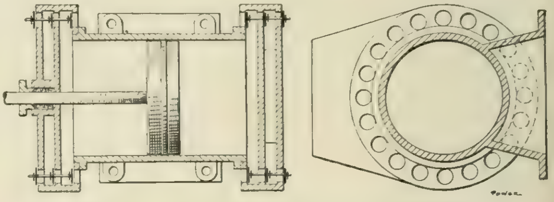


FIG. 4. EUROPEAN BLOWING CYLINDER

Of course, if the port gets cut and it is necessary to rebore it, a reserve valve will not fit, but that condition is by no means usual. In most cases an extra valve will fit any of the ports in a cylinder. In the machine described, all the valves are moved positively, the actuating piston only determining the position of the fulcrum block in its curved path, so that the outlet valve may open at the proper time.

If the actuating piston should fail to work, the machine would still pump its full capacity of air, the inlet valves opening and closing and the outlet valve closing at the proper time, while the opening of the outlet valve only would be deranged, which would not seriously affect the operation of the machine. With this type of machine it is impossible for the blast to blow back through the machine, due to breakage or derangement of the gear, something which cannot be said of plate valves. Indicator diagrams taken from such a machine show a most satisfactory distribution of air.

R. C. Holman.

Lynn, Mass.

Engineer's License Laws

Mr. Behen's letter, in the Apr. 21 issue, helped to again arouse my indignation toward the careless manner in which our lawmakers have spent their time at various state capitols revising, remodeling and building laws of little or no consequence to most people. Mr. Behen thinks that West Virginia should have strict license laws. Well, this is not the only state; there are plenty of others.

While I was engaged in erecting stokers at a coal mine in Pennsylvania a few years ago, they had a small firebox boiler for temporary use which they had loaned to a farmer earlier in the fall. The farmer came back and informed the master mechanic that he had fired the boiler as hard as he could for two days and could not get over 7 lb. of steam. The gage had been sprung and the only water in the boiler was in the water leg. The boiler was not so valuable after that.

In a sawmill in Michigan that was being rebuilt and prepared for a run, was a small duplex pump that had had the exhausts plugged upon being shut down after the previous run. The engineer and the master millwright were quoted as saying that as it was a cold-water pump it needed no exhaust; still, they were at a loss to know why it could make but a few strokes and then would come to a standstill.

After taking out one of the plugs as advised by one of the millwrights, the engineer smiled like a boy with a new toy to see how nicely the pump would run. The main point, however, is that we need some sort of regulations governing the operation of power plants. At the present time, I believe the federal government issues licenses after proper examinations to engineers on the lakes and the ocean, but in most of our cities, as far as the law is concerned, any one who knows the throttle from the blowoff can jeopardize the the lives of many persons in office buildings and factories.

I think it is about time "Uncle Sam" exercised some authority in compelling the various states to frame a system of "Safety First" laws for power plants, and letting uniform divorce laws lay over on the table for another week or two.

R. E. Keech.

Elkins, W. Va.

It may be consoling to Walter B. Behen to know that there are underpaid engineers in places where there are license laws. Ontario has a government license law but it is easy to find engineers working 12-hr. shifts for from \$12 to \$15 per week. In lower Canada a lot of them work for even less. Toronto City pays laborers, including street sweepers, \$15 per week. There are hundreds of firemen and assistant engineers in Toronto and other places receiving from \$25 to \$50 per month, including board. The last item would be worth about \$12 to a single man; to a married man, next to nothing. There are many chief engineers in Ontario, good men, receiving from \$75 per month up, but it is only in important plants.

A license law is good for the employer, as it makes better engineers, but it does not mean more pay for the engineer in all cases. It is a fact that the pay for engineers in small or average plants has not increased for many years, as it has with almost, if not all, other mechanical workmen.

Twenty years ago and more the technical press had practically the same editorial matter in connection with this complaint from engineers as they have now. We appear to be afraid to demand our rights.

James Ellethorn.

Toronto, Ont., Canada.

Care of Boiler during Shutdown

I agree with F. E. Worley, in the Apr. 21 issue, page 565, that a boiler should be cleaned outside and inside, but if left emptied, it should be carefully dried, and not left to be air dried. It is difficult, however, to understand how so much rust could collect on the tubes if a boiler is filled with water and the temperature of the water is raised to that of the air at the time of filling. No rust should collect, because the water will adapt itself to the outside temperature or weather changes.

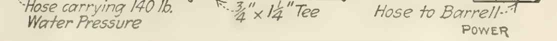
With a large number of return-tubular boilers used during the winter months and left full of water during the summer, I have never seen a sign of rust on any of the tubes. Surely there is no country where the atmospheric changes are greater than here.

Morris E. James.

Toronto, Ont., Canada.

Cleaning Storage-Battery Cells

The usual method of getting rid of the sediment which accumulates in the bottom of storage-battery cells is to take the plates out of the jars before cleaning them. When the plates are removed from the jars the old separators become useless and have to be replaced with new ones. This all takes considerable time, and when the battery is of 50 amperes or more capacity, the job of cleaning is not the most desirable, to say the least.


$\frac{3}{4}$" Hose to Jar
$\frac{3}{8}$" Pipe threaded all the way back, reduced at the end to $\frac{1}{8}$"
Hose carrying 140 lb. Water Pressure
$\frac{3}{4}$" x $1\frac{1}{4}$" Tee
Hose to Barrell
POWER

Ejector for Siphoning Contents of Jars

Recently it became necessary to remove the sediment from the jars of a 132-cell, 50-ampere battery in a plant with which the writer is familiar. A method somewhat resembling the one described by Mr. Dawson in the Dec. 9, 1913, issue of POWER, was used. Instead of removing the plates from the jar, however, they were left in place while the cleaning was going on. A home-made injector was made up of a $\frac{3}{4}\times1\frac{1}{4}$-in. tee and some fittings (see sketch), and was made portable so that it could be carried between the rows of cells. In this case water at 140 lb. was used to operate the siphon, although the arrangement will work with steam or compressed air. There is space enough between the jar and the plates to admit the $\frac{3}{4}$-in. hose. The acid was first siphoned out and was used again for the same purpose. After all the sediment was removed and the jar flushed until clean, the acid was replaced. Except in isolated cases, it was not necessary to replace the old separators with new ones. This method of cleaning saved time and the cost of nearly an entire set of new separators, besides eliminating much heavy lifting.

H. G. GIBSON.

Washington, D. C.

Repair to an Armature

A 1500-kw., 600-volt, direct-current generator, operating in parallel with two similar machines and supplying power to a street-railway system, suffered a severe burnout in its armature, several coils being destroyed.

When the armature was examined, it was found that one of the coils had grounded to the core. As the negative side of the system is grounded, this resulted in a large current flow, a hole about 2 in. in diameter and 2 in. deep being burnt into the armature core. The repair was made as follows:

The armature being cleared of the burned-out coils, the hole was chiseled out until it was 3 in. square and $2\frac{1}{4}$ in. deep. This was rendered easier as the hole was burned close to one edge of the core. Care was taken to carefully file off all burrs resulting from the chiseling. A laminated block was next made up to fit exactly the hole, the laminations being shellacked before being riveted together. The laminated block was then placed in a milling machine and slots cut in it to correspond with the slots in the core. When a good fit was secured, the core was drilled and tapped and the block held in place by two countersunk screws. Care was necessary in drilling and tapping the core.

After the coils were replaced, the machine was started and has since run almost continuously without the slightest evidence of local heating.

EDWIN L. HINCHLIFF.

Duluth, Minn.

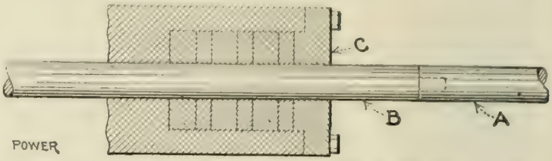
Replacing a Wristpin Brass

A wristpin brass on a 100-hp. tandem gas engine ran hot and had to be scraped and refitted. This in itself was not much of a job, but, on account of the construction of the engine, getting the brass out and in again was quite a task and as the engine could not be spared during the day, the work had to be done at night.

The engine is a two-cylinder, single-acting tandem machine with both pistons on the same rod, and a stuffing-box in the front head for the piston rod to pass through. In order to get the wristpin and brass out, the rear cylinder head had to be taken off, the rear piston taken off the rod, the connecting rod disconnected from the crank-pin brass and the front piston pushed ahead until the pin cleared the forward end of the front cylinder. The pin could then be removed and the brass and connecting-rod taken out intact.

When the piston was pulled forward enough to do this, the back end of the piston rod would be through the stuffing-box and the garter springs on the metallic packing would close up the packing until it would be impossible to get the rod entered again.

It was the usual custom to take out the packing cage, but this time I set out to devise some way to shorten the work. The sketch shows how it was accomplished; *a* is a piece of shafting of the same diameter as the piston rod, *B* is the rod and *C* the packing cage. The shaft was bored out in a lathe to fit over the threaded part of the piston rod and fit up against the shoulder as shown. When the piston rod passed through the packing, the shaft entered and held the rings expanded until the rod was ready to go back, when the operation was reversed. This saved taking the packing cage out and replacing it, which meant at least an hour's work, and most engineers know how to appreciate an hour when they have worked from 6:30 a.m. until 10:30 p.m.



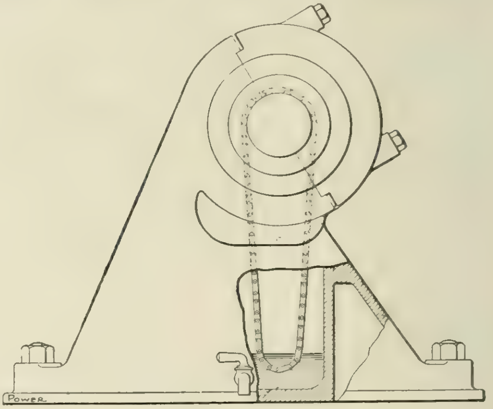
MEANS FOR REMOVING PISTON ROD WITHOUT GLAND PACKING COLLAPSING

EARL PAGETT.

Coffeyville, Kan.

Bicycle Chain as Oil Carrier

The original brass-chain oil conveyor on the outboard pedestal bearing wore through. A bicycle chain was substituted and it proved more satisfactory by reason of its greater weight.



BICYCLE CHAIN

EDWARD T. BINNS.

Philadelphia, Penn.

Building a Smokeless Furnace

In the issue of April 21, under the above heading, is an article by Mr. Shoemaker, which all are invited to discuss.

To burn anthracite coal in a furnace designed for bituminous coal is as bad as burning bituminous in a furnace designed for anthracite, therefore the economy claimed by Mr. Shoemaker is not only possible but natural. There is no more reason to expect good economy from the use of one furnace for all kinds of fuel than from the use of one pair of shoes for a whole family consisting of father, mother and a two-year-old boy.

Mr. Shoemaker says: "I find it much better to set the boiler at least 36 in. above the grates. I do not carry the bridge-wall more than 14 in. above the grate surface and extend it straight across the furnace. The object is to keep the shell away from the fuel so that when using long-flame bituminous coal, complete combustion will take place before the flame strikes the shell." Does this accomplish the object?

From my observation of furnaces in which boilers are set from 24 to 52 in. from the grate to the shell, the flames always hug the shell of the boiler during the distillation period of the fuel.

Further on, we have the following: "One method I have used to prevent smoke is to run three or more small air ducts behind the fire-brick lining of the inside wall of the furnace with openings so that the air can enter these ducts just beneath the grate surface, and open the outlet of the air duct in the side walls to a level with the lowest portion of the boiler shell." He then says: "The principle of this method is to have a slight blanket of highly heated air in contact with the boiler shell above the fire and bridge-wall and keep the flame from striking the shell." The principal claims for the method are chimercial and the virtues are imaginary, for an impossibility is claimed.

To accomplish the protection of the boiler from the flames or the flames from the boiler "with a slight blanket of highly heated air," the air must cover the shell of the boiler. To do this it must travel from the side wall to the shell at right angles to the force of the draft which made possible its entrance into the furnace, and then at 180 degrees, 90 degrees toward the fire door and 90 toward the bridge-wall. If there is no other force to project the air and neutralize the effect of the draft, the air so admitted will be controlled by the force of the draft, and as soon as it enters the furnace it will be pulled toward the flues and its direction will be but coincident with the pull of the draft. The benefit of the air admitted into the furnace in the manner indicated will be limited by the amount of unburned gases passing along the side wall with which it may mix.

I expect that Mr. Shoemaker will ascertain the facts for the benefit of Power readers; they can be easily ascertained. First, take the idle boiler, place ignited oiled waste at the intake in the ashpit, close the fire-doors and open the damper. The direction of the air entering into the furnace will be indicated by the smoke taken with it, and a person on the grate with an extension light can easily see where it goes and determine whether the air forms a blanket about the boiler or makes a bee line for the stack.

Then seal the intake into the air duct, other conditions being unchanged, and note the effect on the smoke and the economy.

H. Misostow.

Chicago, Ill.

Spherical Boiler Heads

In Power for Jan. 13, T. T. Parker rightly points out that it is incorrect to calculate the strength of spherical boiler heads by treating them as spheres. The rule he suggests, however, perpetuates this error, although by using a larger factor he minimizes the risk of arriving at dangerously light plate thicknesses.

As a matter of fact, any rule of the form

$$t = \frac{R \times factor \times P}{T.S.}$$

assumes that the head is stressed as a sphere and is in consequence essentially incorrect. The stress in a sphere is a simple tensile stress without any bending whatever, but in the case of most spherical boiler heads there is a considerable bending stress of indeterminate amount.

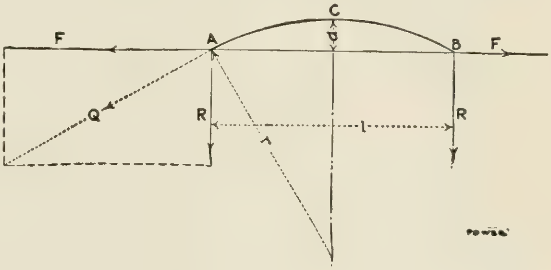


Fig. 1.

The fact is that the manner in which the head is stressed is determined, not by its shape, but by the stiffness of the shell into which it is riveted. The radius of curvature of the spherical portion has not necessarily any direct relation to the stress in it.

It is a somewhat difficult matter to grasp this problem, but by considering a cambered beam subject to a uniform radial pressure, the idea becomes clearer. The stresses in a cambered beam can be worked out quite closely and the analogy between it and a spherical head is sufficiently good to enable one to form a reasonably correct view of the nature of the stresses.

In Fig. 1, *ACB* is a cambered beam of radius *r*, the versin being *d*, and the chord $AB = l$. The beam is subjected to a uniform radial load of *p* pounds per square inch, and is supported at the ends, each reaction being equal to *R*.

The bending moments acting at the center of the beam are:

Bending moment due to reaction =

$$R \times \frac{l}{2} = p\frac{l^2}{4} \left(since\ R = p\frac{l}{2}\right)$$

This acts downward and will be designated as +.

Bending moment due to the vertical component of the radial force =

$$-p\frac{l}{2} \times \frac{l}{4} = -p\frac{l^2}{8}$$

Bending moment due to the horizontal component of the radial force =

$$-p \times d \times \frac{d}{2} = -p\frac{d^2}{2}$$

The resultant bending moment is, therefore,

$$p\frac{l^2}{8} - p\frac{d^2}{2} \qquad (1)$$

Now introduce at A and B horizontal forces F, pulling on the ends of the beam. These forces produce a bending moment which is a maximum at the center of the beam and $= F \times d$. This bending moment acts in a sense contrary to that produced by the reaction and, therefore, may be considered negative. The resultant bending moment now becomes

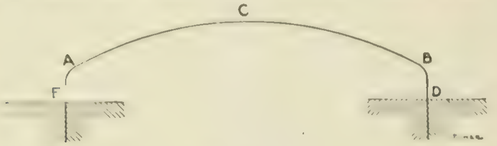


FIG. 2.

$$p\frac{l^2}{8} - p\frac{d^2}{2} - Fd \qquad (2)$$

Combine the forces F and R into a single force Q, and it may be shown that the sum of the quantities in (2) is zero, when Q is tangential to the beam at the ends, its value being $p \times r$, which is recognized as being the stress in a cylinder under fluid pressure.

If, therefore, instead of supporting the beam at the ends it is attached by pin joints to supports capable of withstanding, without deflection, a pull equal to $p \times r$, the bending moment is eliminated and the beam is stressed as a cylinder. On the other hand, if the supports are not stiff enough to withstand a pull of $p \times r$ without deflection the beam is subject to a bending moment. It appears, therefore, that the nature of the stress in the beam is determined, not by its shape, but by the manner in which it is attached to surrounding parts.

To extend the case now to a beam of the shape shown in Fig. 2, consider this as being made up of a circular arc ACB jointed by pin joints at A and B to abutments EA and DB. From the preceding arguments it is evident that the part ACB can only be considered as under no bending moment on the assumption that the end parts EA and DB are able to withstand without deflection a horizontal pull equal to F, where

$$F = \sqrt{Q^2 - R^2}$$

$$R = \frac{pl}{2}$$

and $$Q = p \times r$$

Suppose, now, the horizontal force actually applied at A is less than

$$\sqrt{Q^2 - R^2}$$

Let this force be represented by Aw (Fig. 3), where F is represented by Az. The effect will be to leave a bending moment on the beam, which will be a maximum at C, where it will equal

$$(Az - Aw) \times d$$

Consider now the case of a dished end under fluid pressure. Using the notation of Fig. 1,

$$R = \frac{pl}{2}$$

$$Q = p \times r$$

and $$F = \sqrt{Q^2 - R^2} =$$

$$\sqrt{p^2r^2 - \frac{p^2l^2}{4}} =$$

$$p\sqrt{r^2 - \frac{l^2}{4}} \qquad (3)$$

It will be seen that when $r = \frac{l}{2}$; that is, when the end is hemispherical $F = 0$ and when $r = l$, $F = 0.866\ p \times r$. The thickness has not been introduced so far and the forces are per inch of width.

Actually in a dished end there is no internal force applied equivalent to F and, as in the case of the beam, a force is only introduced by the resistance to deflection. When dished ends have been tested and the deflection gaged it has been found that the crown (C) moves out and those parts of the circumference (A and B) come in showing that the annular ring of metal around the circumference is in compression. The resistance to compression of the outer ring, therefore, provides the force F, and unless this resistance is sufficiently great, the cambered part cannot be correctly treated as spherical, as regards the way in which it is stressed.

If the cambered part is to be treated as being stressed in tension, that is, as a sphere, it follows that the resistance to compression of an annular ring at the circumference equals a radial force

$$F = p\sqrt{r^2 - \frac{l^2}{4}}$$

In order to get a rough idea of the possible intensity of compressive stress which would be induced by a radial force equal to F, we will take one of the ends tested by Bach in his classical experiments. In this case r was 40.5 in.; t, 0.39 in.; l, 24 in., and p, 205.8 lb. per sq.in.

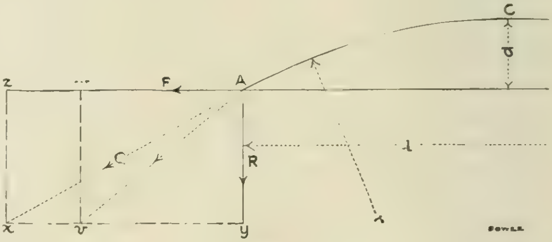


FIG. 3.

Therefore, $$F = p\sqrt{r^2 - \frac{l^2}{4}} = 7950\ lb.$$

We are quite in the dark as to the depth of the circumferential ring, which may be regarded as being in compression, but suppose it be assumed to be 3 in. deep, and let f be the compressive stress on this ring 3 in. deep by 0.39 in. thick, due to a radial force of 7950 lb. per sq.in.; then,

$$f = \frac{7950 \times 24}{2 \times 3 \times 0.39} = 81{,}500\ lb.$$

It is improbable that such stresses actually occur and it is more reasonable to suppose that the case is analogous to that of the beam, first considered, and that the cambered part offers resistance to buckling and is not by any means stressed as a sphere.

The right way to regard a cambered boiler end would appear to be to treat it in the same way as a flat plate which would then become the limiting case where the radius is large. The formula for the safe pressure of cambered ends would then contain the area of the end and the depth of the versine as factors together with a coefficient and the square of the thickness, thus

$$p = \frac{C \times t^2}{S}$$

where

p = Safe pressure in pounds per square inch;

t = Thickness;

S = Area of end;

C = Coefficient depending on the ratio of versine to radius of camber.

A. C. Wilson.

Manchester, England.

Tests of a Simple Noncondensing Lentz Engine

In the issue of Dec. 2, 1913, was given an account of tests carried out by Prof. J. A. Moyer on a 19x21-in. simple noncondensing Lentz engine built by the Erie City Iron Works. The economies and heat consumption obtained by this engine were so remarkable that a discussion of these tests is very appropriate.

The writer, having introduced the Lentz engine into this country and having designed the engine in question, can approach this subject without any prejudice whatever, although occupied at present in competitive lines.

In Table 1, the figures as published are recapitulated, and in the last column are added the Rankine efficiencies, based on adiabatic expansion to wet steam at the terminal pressure given.

TABLE 1. RESULTS OF TESTS ON A SIMPLE LENTZ ENGINE

No. of Test	Duration of Test, Hr.	Speed, R.p.m.	Mean Effective Press., Lb. per Sq.In.**		I.hp.	Steam per I.hp. per Hr., Lb.	Absolute Steam Pres., Lb. per Sq.In	Back Press., In. of Mercury	Superheat, Deg. F.	Rankine Eff., %
			H.E.	C.E.						
1	4	208	46.35	45.92	282.1	15.24	170.3	0.34	141.5	85.8
2	3	208	24.83	28.40	162.7	17.25	170.1	0.00	98.3	77.8
3	3½	211	36.19	37.08	227.6	15.78	171.9	0.00	139.4	82.9
4	1†	207	53.40	52.22	322.5	15.48	171.7	0.10	159.7	82.7

**Calibrated scales of springs of indicators are respectively, 78.9 and 79.3 lb. per sq.in.

†Generator would not carry load for a longer time on account of heating.

While tests Nos. 1, 3 and 4 correspond closely as to the Rankine efficiency, decreasing with the decreasing number of expansions, test No. 2 seems to differ very much. There is no apparent reason why the efficiency in the latter case should be about 8 per cent. less than that of test No. 1. On account of the lower superheat a difference of about 1 per cent. may be expected, all other conditions remaining the same, but the more complete expansion maintained during test No. 2 should tend to increase the efficiency.

It is impossible to form a logical explanation for this discrepancy, but the exhaust temperatures, Table 2, may supply a basis for approaching this problem.

TABLE 2.

No. of Test	Steam Consumption per I.hp.-hr., Lb.	Abs. Steam Pres., Lb.	Temp. of Exhaust, Deg. F.
1	15.24	170.3	220.3
2	17.25	170.1	212
3	15.78	171.9	223.6
4	15.48	171.7	235.3

From my own observations during the tests I can vouch that all readings were observed with the greatest care, and the instruments were carefully calibrated. However, the exhaust temperatures observed in tests Nos. 1, 3 and 4 (test No. 2 will not be discussed on account of the absence of a calorimeter reading) seem to indicate that an error has crept in which apparently could not have been detected by those conducting the test.

In my opinion it is not probable that a mistake was made in determining the steam consumption as the observations made at certain intervals during the tests checked up very closely and I am inclined to consider the exhaust temperatures as correct. I have, therefore, come to the conclusion that the superheat maintained was considerably higher than indicated by the calibrated thermometers.

With this assumption Table 3 was calculated, giving in column 5 the amount of superheat apparently carried in the steam chest, in column 4 the B.t.u. actually converted into work per pound of steam, and in column 6 the same, but for adiabatic expansion.

TABLE 3.

No. of Test	Steam Press. Abs., Lb.	Steam Cons. per I.hp.-Hr., Lb.	Temp. of Exhaust, Deg. F.	Work Done per Lb. of Steam, B.t.u.	Superheat, Deg. F.	Work Done per Lb. of Steam During Adiabatic Expansion, B.t.u.	Rankine Eff., Per Cent.
1	170.3	15.24	220.3	167	236	212	78.7
3	171.9	15.78	223.6	161	226	210	76.7
4	171.7	15.48	235.3	165	246	214	77.2

Take, for instance, test No. 1. We know the exhaust contains about 1154 B.t.u. per pound, also that during expansion 167 B.t.u. were converted into work per pound of steam. Hence the steam on entering the cylinder must have contained approximately 1321 B.t.u. per pound (neglecting radiation) and with a pressure of 170 lb. absolute a superheat of 236 deg. F.

If using the Mollier diagram instead, we locate the point where the curves of 15 lb. pressure and 8 deg. superheat intersect, then passing vertically upward a distance representing 167 B.t.u., following this abscissa until we intersect the curve of 170 lb. pressure, a superheat of about 236 deg. is indicated. The vertical distance from this point to the 15-lb. pressure line represents the work of 1 lb. of steam in B.t.u. during adiabatic expansion.

Naturally, the question arises whether or not it is possible that a much higher superheat than indicated by the thermometers was actually carried, a question which must be answered in the affirmative in view of the experiments carried out by Dr. Armand Duchesne, of the University of Liége. V. Dwelshauvers-Dery, late professor emeritus of the University of Liége, in discussing the investigations of Duchesne, writes:

"Two difficulties are to be found in the measurement of the temperature of superheated steam passing even slowly through a space, as a pipe. First, the temperature is not uniform throughout the mass as it would be with saturated steam, on account of the slow conductibility of the superheated fluid. An instrument is necessary which gives the average temperature, as the piston of the indicator gives the average pressure, and instantaneously as does the indicator piston. In this connection it is safe to say that the mercury thermometer can give only the local temperature, and that tardily, especially if it is in a cup of oil. The hyper-thermometer of Duchesne with its numerous junctions disseminated through a large space and its excessively small mass sensible to heat, meets these conditions as far as is practically possible.

"The importance of the effect of these two factors will be appreciated when it is remembered that in some of the experiments the difference between the mercury thermometer in its oil bath and those of the more responsive and sensitive thermocouple amounted to more than 80 deg. C. (144 deg. F.)."

The investigations of Duchesne showed, furthermore, that with saturated steam a temperature for all purposes constant and uniform was obtained, no matter whether determined by the mercury thermometer or by the hyper-thermometer of Duchesne and that the error increased with the increasing superheat and decreased with increasing pressure.

The explanation given by Duchesne of the difference between the temperatures indicated by the hyper-thermometer and the mercury thermometer involves, according to Dwelshauvers-Dery, the hypothesis that in the body of the same mass of superheated steam are to be found contiguous layers or strata of steam of different temperatures. Hirn had already remarked this, and Duchesne has demonstrated it experimentally. He has shown even that there may exist strata of saturated steam. In brief, then, one first point is established that with superheated steam all observations of temperature may be false if not made with a thermometer practically without mass.

In adopting the views and experiments of Duchesne as being correct, one must come to the conclusion that in the tests of the Lentz engine the exhaust temperatures are approximately correct, while the corresponding temperatures taken in the steam chest are subject to the discrepancies due to the inadequate instruments used.

There are other reasons which convince me that my assumptions are correct. A test was carried out after completing the above tests to determine also the economy of the engine running with saturated steam and the following results were obtained:

TABLE 4.

Duration of Test, Hr.	Speed R.p.m.	Average I.hp.	Steam Consumption per I.hp. per Hr., Lb.	Abs. Steam Pres., Lb.	Moisture, Per Cent.
4	208.9	230	25.2	175.1	4.13

An allowance of 3 per cent. for each 1 per cent. of moisture can justly be given as condensation is increased by the presence of moisture. With this correction the consumption of perfectly dry steam would become 22 lb. per i.hp.-hr. with a Rankine efficiency of 65 per cent. This consumption is reduced by about 30 per cent., as shown in test No. 3, Table 1, due to the superheat, a saving which to all previous records of poppet-valve engines may well be expected with 250 deg. superheat but impossible with 140 deg. superheat. These records show that 250 deg. superheat will lower the steam consumption of a compound engine approximately 23 per cent. and that of a simple engine 28 per cent., figures which emphasize the correctness of my assumption that the superheat carried during the test was about 240 deg. F.

The following also seems to support my conclusions: A test was made by the R. W. Hunt Co., of Chicago, on a 15x21-in. simple noncondensing Lentz engine installed at the Throop St. plant of the Peoples Gas, Light & Coke Co., Chicago, Ill. In this case an economy of 18.6 lb. per i.hp.-hr. with 147.6 lb. gage pressure and 49.5 deg. F. superheat was obtained, giving a Rankine efficiency of 75.9 per cent.

The 17x21-in. simple noncondensing Lentz engine installed at the plant of the Randall-Faichney Co., of Jamaica Plains, Mass., showed a Rankine efficiency of 78.4 per cent. and a steam consumption of 17.2 lb. per i.hp.-hr. when operated with 140 lb. pressure and 150 deg. superheat.

The plain tube superheater used during the test conducted by Professor Moyer on the 19x21-in. Lentz engine was undoubtedly capable of producing the superheat assumed in Table 3. It was placed just behind the bridge-wall of a horizontal water-tube boiler of the Erie City type and sheet-iron baffle-plates were so arranged that the gases impinged directly on the superheater after having been in contact with the lower bank of tubes.

From my own observations in a previous test I noticed that the thermometer on the superheater outlet indicated 200 deg. F. superheat while that placed at the engine about 30 ft. away showed a superheat of about 90 deg., though the pipe line was well covered with nonconducting material. At that time I was unable to find a reason for this difference in readings.

In summarizing it has to be admitted that tests Nos. 1, 3 and 4 of Table 1 do not correspond with tests made on other engines of the same type and built by the same concern. Of particular interest is the Rankine efficiency of 65 per cent. of the 19x21-in. engine when working with dry-saturated steam as it is obviously impossible that this efficiency could be increased by 18 per cent. when operating with 140 deg. superheat while an increase of about 12 per cent., as given in Table 3, with 240 deg. of superheat can be expected with the cylinder design used. In this particular case the engine was not operated under the most favorable conditions as the cylinder was originally designed for a 21-in. bore and in decreasing the diameter to 19 in. the clearance volume was materially increased, making it about 12 per cent., also materially enlarging the clearance surface.

It is my opinion that even with the modified figures of Table 3 the results are remarkable though by no means world's records. It is my firm belief that better economies can be obtained in a poppet-valve engine where clearance in surface and volume is reduced to a minimum, with the emphasis on the former. The possibility of entirely machining the clearance surface would enhance the value of such design. The recent experiments carried out in Professor Bach's laboratory at the Technical College of Stuttgart prove again the importance of this much neglected arrangement.

In concluding I should recommend on account of the obvious difficulty in reading superheats correctly with the instruments ordinarily in use, that in such cases the exhaust temperatures be read and calorimeter readings be taken in order to arrive at more accurate results.

S. Rosenzweig,
Consulting Engineer, York Manufacturing Co.
York, Penn.

Inquiries of General Interest

Taper of Pipe Screws—What is the standard taper for screw-threaded ends of wrought-iron pipe?

W. J.

The length of tube end throughout which the screw continues perfect should have an inclination to the axis of the tube of 1 in 32, i.e., a total taper of ¾ in. to the foot.

Effect of Soda Ash on Pump Valves—Will feeding soda-ash solutions through boiler feed pumps injure rubber pump valves?

J. D. R.

A soda ash solution will deteriorate rubber pump valves to some extent, but not seriously when fed along with boiler-feed water in the proportions usually required in a boiler compound.

Overheating Boiler Sheet—In operation of a horizontal return-tubular boiler carrying 125-lb. pressure with two gages of water, is there any possible way the lower part of the front sheet could get red hot?

E. S.

Yes; if the sheet on the inside of the boiler is so covered with scale or other nonconducting material that the heat received by the sheet cannot be transmitted to the water, then, with a hot fire, the sheet would become red hot.

Finding Approximate Temperature of Uptake Gases—How can the temperature of the uptake gases of a boiler be approximately determined without using an ordinary pyrometer or thermometer?

G. N.

The temperature can be approximately determined by noting the effect which the heat of the gases has on small pieces of substances that fuse at different known temperatures when hung on iron wires in the uptake. Fusion of tin occurs at 449 deg. F.; bismuth at 518 deg. F.; lead at 621 deg. F., and zinc at 786 deg. F.

Noise in Flywheel—What may be the cause of a rattling or crunching noise in the flywheel of an engine except when the steam lead of the crank end is late or when the cutoff is earlier on the head end than on the crank end?

W. E. F.

The noise may be caused by a cracked flywheel, or by riding of the key due to improper fitting of the key or to springing of the shaft. Noise from a key will sometimes be stopped by bringing the shaft to rest with the key way at the top and leaving the shaft stand over night with the key way thoroughly flushed with thin lubricating oil.

Measuring Eccentricity of Eccentric—How would the eccentricity of an eccentric be measured?

R. B. C.

Caliper the diameter of the eccentric and the diameter of the shaft, and the eccentricity will be found by adding together one-half of the diameter of the shaft and the distance the "high side" of the eccentric projects from the shaft, and deducting one-half of the diameter of the eccentric; or by adding together one-half of the diameter of the shaft and the distance the "lowest side" of the eccentric projects from the shaft and deducting their sum from one-half of the diameter of the eccentric.

Inch of Mercury or of Water—What is the value in pounds or ounces of pressure per square inch of 1 in. of mercury and of 1 in. of water?

E. P.

The difference in level of water or mercury in the branches of a manometer or U-tube indicates difference of pressure acting on the surfaces of the liquid in each branch and the weight in pounds per cubic inch of the liquid employed will be the difference in pressure per square inch for each inch difference in height, commonly called 1-in pressure of the liquid. At 62 deg. F., 1 cu.in. of mercury weighs 0.491 lb., and 1 cu.in. of water weighs 0.03609 lb., therefore, at this temperature "1 in. of mercury" would represent a pressure of 0.491 lb., or 7.86 oz. per sq.in., and 1 in. of water 0.03609 lb., or 0.5774 oz. per sq.in.

Cast Steel and Steel Castings—What is the difference, if any, between cast steel and steel castings?

A. N. G.

Cast steel is the name usually confined to fine-grained steel from which high grades of cutlery and tools are forged. It is made by cutting up wrought iron into small pieces which are melted in covered crucibles, the desired amount of carbon being placed on top of the charge before the melting, together with any other alloying element desired, such as chromium, tungsten, manganese, etc. After being melted and thoroughly mixed the charge is cast in the form of an ingot for hammering and rolling. Steel castings may be any kind of steel melted down and cast into molds in the manufacture of steam fittings or other articles in the same manner that iron castings are made from iron.

Alternate Firing—What is meant by alternate firing and what are its advantages?

C. J.

Alternate firing consists in spreading fresh coal first on one-half of the bed of the furnace and then on the other half at equal intervals of time, alternating either on the front and rear or on the right and left side of the furnace. The advantages of this method of firing are that the volatile gases arising from each addition of fresh coal are brought in contact with the current of hot gases, carrying an excess of air, which arise from the half-burned coal on the other half of the grate resulting in more perfect combustion of the volatile matter. With a large combustion chamber in which the gases can become thoroughly mixed before coming in contact with the heating surfaces of the boiler, alternate firing, when skilfully performed, may largely prevent smoke.

Steam Supplied to Tenant—Dry steam at 120-lb. boiler pressure is supplied to a tenant for heating the coils of a drying room. There being 850 lb. of condensate returned per hour at the temperature of 212 deg. F., what is the equivalent boiler-horsepower?

W. W.

Referring to the steam tables it may be seen that to raise a pound of water 32 deg. F. into steam at the pressure of 135 lb. per sq.in. absolute (which is approximately the same as 120 lb. per sq.in. boiler pressure) would require about 1192 B.t.u.

The condensate, returned at 212 deg. F., would contain,

$$212 - 32 = 180 \text{ B.t.u. per lb., above 32 deg. F.,}$$

and, therefore, the net service would amount to

$$(1192 - 180) \times 850 = 860{,}200 \text{ B.t.u. per hour,}$$

and as a boiler-horsepower is equivalent to 33,479 B.t.u. per hour, the service would be equivalent to

$$\frac{860{,}200}{33{,}479} \text{ or 25.7 boiler-horsepower.}$$

Obtaining Length of New Connecting Rod—How would the correct length of a new connecting rod for an engine be determined from the old rod?

W. H. L.

After properly adjusting the piston rod to the crosshead, the length of new rod should be determined with reference to obtaining equal clearance of the piston at each end of the cylinder. For this purpose, disconnect the rod from the crosshead and make a mark on the crosshead and corresponding marks on the guide when the piston is firmly against first one end and then the other end of the cylinder, the marks thus made on the guide representing the extreme travel of the piston. Next reconnect the old rod and placing the engine first on one center and then on the other, make marks on the guide corresponding to the mark on the crosshead, to represent the length of the stroke. Comparison of the distances apart of the marks made on the guide representing the extreme travel of the crosshead before and after connecting the old rod, will indicate how much longer or shorter the new rod should be between centers of the crank and crosshead pins with equalization of piston clearance.

Engineers' Study Course

Elementary Mechanics--X

LAST LESSON'S ANSWERS

41. Divide the angle (see Fig. 10) into the two rectangles *OABCO* or *I*, and *DCFED* or *II*. The *c.g.* of rectangle *I* will be at the point *M*, which is the point of intersection of the two diagonals *AC* and *OB*. Likewise, the *c.g.* of the rectangle *II* is at the point of intersection *N* of the diagonals *CE* and *DF*. Draw the reference axes *OX* and *OY*, and assume the *c.g.* of the angle to be located at the point *G*, *X* inches from the *OY* axis and *Y* inches from the *OX* axis. The area of the figure *I* is

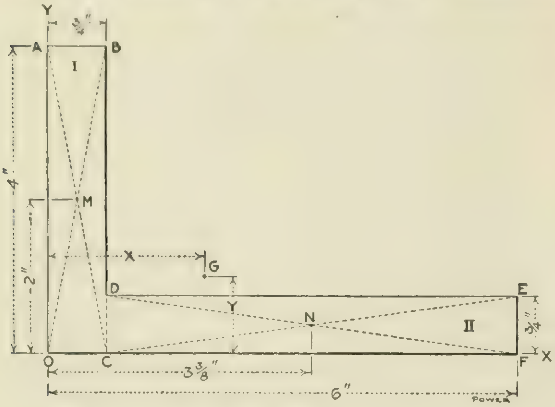


FIG. 10.

$$\tfrac{3}{4} \times 4 = 3 \ sq.in.$$

and the area of figure *II* is

$$\tfrac{3}{4} \times 5\tfrac{1}{4} = 3.94 \ sq.in.$$

Then the total area of the angle is

$$3 + 3.94 = 6.94 \ sq.in.$$

The point *M* is 2 in. from the *OX* axis and 3/8 in. from the *OY* axis; also, the point *N* is 3/8 in. from the *OX* axis and 3 3/8 in. from the *OY* axis. These areas may be substituted in equations (11) and (12) in place of w_1, w_2 and *W* since the weight of the angle is proportional to its area. Thus

$$AX = a_1x_1 + a_2x_2$$

and

$$AY = a_1y_1 + a_2y_2$$

where

$$a_1 = 3 \quad x_1 = \tfrac{3}{8} \quad y_1 = 2$$

$$a_2 = 3.94 \quad x_2 = 3\tfrac{3}{8} \quad y_2 = \tfrac{3}{8}$$

$$A = a_1 + a_2 = 3 + 3.94 = 6.94$$

substituting these values in the above equations

$$X = \frac{a_1x_1 + a_2x_2}{A} = \frac{(3 \times \frac{3}{8}) + (3.94 \times 3\frac{3}{8})}{6.94} = 2.08 \ in.$$

and

$$Y = \frac{a_1y_1 + a_2y_2}{A} = \frac{3 \times 2 + 3.94 \times \frac{3}{8}}{6.94} = 1.08 \ in.$$

42. The beam is in unstable equilibrium.

43. A cylindrical tank lying on its side; (b) the spherical weight used on fly-ball governors, when the weight is resting on a horizontal surface.

44. The *c.g.* should be as low as possible so as to reduce the possibility of overturning the truck when rounding curves.

45. In neutral equilibrium.

SUMMARY OF CONDITIONS OF EQUILIBRIUM

When any number of forces which are either concurrent or nonconcurrent and lie in the same plane, tend to produce a state of equilibrium it has been shown that certain general conditions must be satisfied by the forces. The first of these conditions is that there can be no resultant force. The second of the conditions is that there may be no resultant horizontal, or vertical component, and for this to be true the algebraic sum of all the horizontal and the vertical components must equal zero. If the forces acting on the body pass through a common point the above conditions are sufficient to insure a state of equilibrium; but if the forces are non concurrent then the third condition, that the algebraic sum of the moments of all the forces about a given point must equal zero, is also necessary to completely determine the state of equilibrium. *A system of forces which is in equilibrium may produce either a state of rest, or a state of uniform motion of the body on which the system acts.* Hence the forces acting on a body which is in a state of uniform motion may be in equilibrium just as well as forces which act on a body at rest.

The following general statements will assist the student in summarizing the work of the preceding lessons and at the same time be an aid in the solution of problems dealing with Statics.

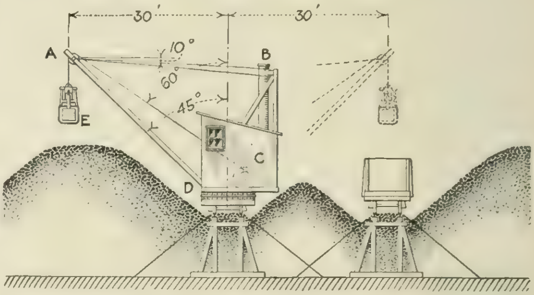


FIG. 41.

For equilibrium to exist when,

CASE I. Two forces act on a body.
The forces must be equal in magnitude, opposite in direction and have a common point of application.

CASE II. Three forces act on a body.
- (a) *The forces must lie in the same plane.*
- (b) *The lines of action of the forces pass through a common point.*
- (c) *The three forces may be represented in magnitude and direction by the sides of a triangle taken in order.*

(d) *If the three forces are parallel the resultant force equals zero, and the algebraic sum of the moments of the forces about any given point equal zero.*

Case III. Any number of forces act on a body.

(a) *If the forces are concurrent and lie in the same plane they can be represented in direction and magnitude by the sides of a polygon taken in order.*

(b) *Any one force is equal and opposite to the resultant of all the other forces.*

(c) *The algebraic sum of the horizontal and the vertical components must equal zero.*

(d) *The algebraic sum of the moments of all forces about any given point must be zero.*

(e) *If the forces are parallel the rule (d) under Case III may be applied.*

It will be noted that in Case I the forces are necessarily concurrent. In Case II the forces may be either concurrent or parallel, and in Case III the forces may be concurrent, parallel or nonconcurrent, and *in all the cases the forces lie in the same plane.*

Problems coming under Case I are solved by making the two forces numerically equal to one another.

Problems coming under Case II are solved, either by applying the law of sines to the triangle of forces, or by the use of equations (8), (9) and (10).

Problems coming under Case II are solved by the aid of equations (8), (9) and (10).

The solution of any problem in Statics may be either analytical or graphical; that is, it may be solved by the use of equations as outlined above, or it may be worked out graphically on the drawing board. The solution of problems by the aid of scale diagrams gives rise to a special form of mechanics called "Graphical Statics," which is particularly applicable to the determining of the loads carried by the various members of roof and bridge trusses, cranes, hoists, etc. While in this course no attempt will be made to discuss "Graphical Statics" it might be well to state that this subject is simply an application of the polygon of forces.

The following study questions are intended to cover the three cases just discussed, to review the work of the previous lessons; further to test the student's ability to analyze his problem, to determine the best method of solution, and last, but not least, to test the student's ability to actually work problems of a practical nature.

Study Questions

46. A boiler stay-bolt makes an angle of 25 deg. with the shell. If the steam pressure is 120 lb. per sq.in. and the stay supports an area 6x9 in., find the pull acting in the stay-bolt.

47. In Fig. 16 (see Lesson IV) let the weight $W = 1000$ lb. and act midway between the points A and B. If the angle $a = 30$ deg., find the tension in the rod AC.

48. In problem 47, determine the direction and magnitude of the pressure at the point B.

49. In the locomotive crane shown in Fig. 41 the total load acting at the point A, due to the weight of the bucket, coal and boom is 4000 lb. The pull in the rope AC is 3500 lb. Find the force tending to crush the boom AD.

50. In problem 49, find the pull in the tie rope AB.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Mebbe, after all, being a mean man has its compensations. This particular feller told his wife that he believed that he hadn't enough friends to make a complete set of pallbearers. His wife told him not to worry. She'd have him cremated and then the ashman could officiate.

* * *

Sensible thing that, of opening the Panama Canal when we needed it, rather than waiting later for the fuss-and-feathers brigade to come down in its pomp and complacency. Our critics to the contrary, there are still a few things we get when we want them in good old Unclesamland, by ding!

* * *

A surgeon **has discovered** that a boy with the appropriate name of Smart has two appendixes, or appendices, take your choice. Smart boy is Smart, who thus seems to have cross-indexed his table of contents.

* * *

Ever pull real hard on your cigar and find that you couldn't even match your smoke with a Ringelmann chart? A bug! Yeppy, it's a tobacco bug, say our national senators. Bet this little cuss is responsible for the "bouquet" (i.e., polite for stink) that emanates from the kind our friends sometimes give us.

* * *

Some classy little kid is Constance, on the "foreword" page! Yes, and Chief Hansom would get a blue ribbon in the high-steppers class. But those two Plymouth Rocks in the background! Perhaps the artist meant them as spare parts, or— Anyhow, it's a good picture, notwithstanding, and a credit to our vocation.

* * *

Astronomer Charley Naylor, the Marshall Field topnotcher, is some nailer when it comes to our miscalling the heavenly bodies. Chas. says "the Martians live in Mars (if anywhere), and not in our Luna." My stars and Jupiter! We went up in the air when we stated that the moon men were Martians. Guess we'll take a correspondence course from the Lick folks. We're licked this trip, anyhow.

* * *

Here's some flattering unction for us practical souls. The national officers of the American Society of Mechanical Engineers are so convinced that the local association is the big means for arousing interest and uplift among professional engineers, that they are going to root tooth and nail for the "locals." You'll learn how they feel about this matter by turning to page 458. Let's see, its some thirty years and more since the national N. A. S. E. officials first started to do this very thing, isn't it? Looks like the "big brother" has got a good hunch.

* * *

An editorial in the "Iron Age" contains this slogan: "Back with the saloon!" Who is? If he's the one man in your neighborhood who can concoct a real mint julep or compound a Mamie Taylor, congratulations to you, brother—and here's how! Perhaps, though, we've missed the main idee; whadcha mean, back with the saloon?

* * *

"WHY DO I WORK IN A POWER PLANT?"

You have read in other parts of "Power" that it was "your paper as well as ours." This column is no exception, so here's your chance to metaphorically wade in the Spillway. This means everybody, from the oiler and the fireman down to the super, and the owner—if he'll come in.

Write on a postal card a short, original answer to this question:

WHY DO I WORK IN A POWER PLANT?

Then mail it to "Power," mentioning your name and address as an evidence of good faith, not to be published, however, if so requested.

Of course, it won't be original for you to just say "To make a living," "Because I can't get another job," or "Because I've gone crazy with the heat," etc. Make it original first of all, and if it's funny, too, why all the better.

"Power" will give a five-dollar goldpiece for the best answer and the Spillway editor will be the judge. We'll all have five dollars' worth of fun out of this contest, and someone will get real money as well. The contest starts right this minute!

Log for Absorption Plant

By C. W. Harnist

In keeping a log for an absorption refrigerating plant, readings taken every three hours are often enough, because conditions will not change much in a plant ordinarily. Furthermore, taken at these intervals they will not be a hardship on anyone.

DAILY LOG-ABSORPTION PLANT

Date 19

	9 00 AM	12 00 NOON	3 00 PM	6 00 PM	9 00 PM	12 00 NIGHT	6 00 AM
TEMPERATURES							
BOILER FEED WATER							
BRINE COOLER							
Inlet							
Outlet							
ABS. WATER ON							
ABS. WATER OFF							
GENERATOR							
WEAK LIQUOR							
STRONG LIQUOR							
GENERATOR — GRAVITIES							
WEAK LIQUOR							
STRONG LIQUOR							
PRESSURES							
BOILER STEAM							
AMMONIA HP							
AMMONIA B.P							
BRINE							
COOLING WATER							
CITY WATER							
GEN STEAM							

ENGINEERS
FM. TO
FM. TO
FM. TO

COAL USED
ASHES
ICE PULLED

CITY WATER METER
Pres Read.
Last Read
Diff.

COUNTER READINGS

AQUA PUMPS
No 1 Reading
Revol
No 2 Reading
Revol.

BRINE PUMPS
No 1 Reading
Revol
No. 2. Reading
Revol

BOILER FEED WATER PUMPS
No 1. Reading
Revol.
No. 2. Reading
Revol.

Power

From the data taken on this log the output of the plant may be computed for any length of time. The gravities and temperatures of the aqua will enable one to reduce the data to some standard by reference to ammonia tables, in order to compare one month's run with another. The counter readings of the various pumps allow of computing the amount of liquid circulated, whether it be brine, weak or strong aqua ammonia or boiler-feed water. The amount of ice pulled and the brine circulated will be a check on the quantity of refrigeration produced. The amount of cooling and city water used is important.

From the number of revolutions of the various pumps their total displacement may be easily computed. Their displacement per revolution may be found once and these, times the the number of revolutions, will give their total displacement.

* * *

Safety Engineering at the Power Plant

By E. E. Clock

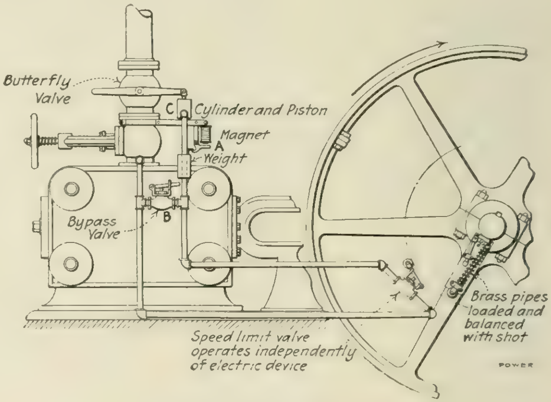
With more than 20 years' experience as an engineer, the last ten as a safety engineer, I have concluded that the public confidence in the engineering profession as a science has been on a basis of faith rather than facts, and that some of the crudities that masquerade as good general practice are little short of criminal.

Regarding safe control of steam engines; the first thought of many, if expressed in words, would be "It's not much of an engineer who can't keep his engine from running away." It is not, however, generally realized that not over 5 per cent. of the steam engines in use are under continual and close manual attendance.

The owner of a plant who would stoutly maintain that his engineer had nothing to do but run the engine might admit under oath that his duties included a great many things, including fixing leaks in the roofs.

Manufacturers locate engines where most convenient, and treat them like other machines; it is not uncommon to find as many as 20 engines located in the plant from the first to the sixth floor, which are visited only periodically and the time between visits is governed only by the capacity of the oil cups.

How are these engines protected against excessive speed and an exploded flywheel? About 50 per cent. of them have no protection at all, about 25 per cent. have an attachment on the governor that is often disabled with the governor, and 25 per cent. are supposed to be protected with some open-circuit electric device that depends upon the integrity of the battery, on open circuit, which in electrical engineering would be a joke, as evidenced by the use of the closed-circuit system on all important work in the electrical-engineering profession, such as burglar alarms, police and fire alarms, ships' signals, etc. Therefore, gross carelessness is found in the matter of safe guarding prime movers against accident.


Butterfly Valve
C
Cylinder and Piston
Magnet
A
Weight
Bypass Valve
B
Brass pipes loaded and balanced with shot
Speed limit valve operates independently of electric device
POWER

Automatic Safety Stop

An engine ought to have two chances to save it from being speeded up beyond its safe limits by the steam held in check by the governor valve. One, called the governor, and the other an independent mechanical speed-limit stop, built into the engine and as widely separated from the governor as possible. Work along these lines has recently been taken up by one or two engine builders.

An engine without a reliable safety stop is in exactly the same position that a boiler would be with a damper regulator and no safety valve, the damper regulator admitting more or less draft, causes more or less steam to be generated and is automatic, but liable to fail. The governor on an engine admits more or less steam to the cylinder and is automatic, but liable to failure. In the boiler the steam to disrupt the boiler must be made, but in the engine it is right there, pushing hard against the governor valve. A safety valve is provided for the boiler, but there is no safety stop for the engine unless put on after leaving the builders. No one would think of locating a boiler in a remote part of the plant with no attendance to speak of, with no safety valve, fed by a mechanical stoker, and controlled only by a damper regulator, but this is done in the case of the engine.

There are two ways by which the present installations of open-circuit electric stop can be made worth while; one is to change it to the closed-circuit system so that its integrity remains visible and its failure must be a self-demonstrating fact as against the invisible, unsuspected failure that does not show up except on test or trial. The other way is to replace the batteries with a generator, then provide a red pilot lamp in the circuit so that when located behind a reflector it will be noticed at once if the current fails.

Some months ago I was called upon to design a safety stop for one of the large steel plants and evolved the one shown herewith. This stop provides for push buttons if desired, but the electric stop is auxiliary to the main stop. The small weight *A* which is released by the magnet is made with a hole through its length and slides on the pipe, as shown. When released by the magnet it slides down the pipe and striking the lever of the valve *B*, opens the bypass valve. The cylinder *C* and its piston, provided to open the butterfly valve, may be used to unhook the lever and the valve closed by a weight on the other end of the lever; this cylinder and piston may be arranged to push the governor up to the top where no butterfly valve is provided.

If the speed-limit valve is made self-closing it simply jumps the butterfly valve shut by short jumps at each strike of the roller on the wheel hub until the wire drawing cuts the speed below the striking speed, and does not stop the engine. With a valve that stays open when struck or with a butterfly valve closed by weight, the engine will come to a standstill after over speeding.

⁂

A Short-Sighted Engineer

By H. L. Lax

The many articles published in the technical press today about the success or failure of the operating engineer and the lack of proper compensation bring to mind a case of extreme short-sightedness on the part of an operating engineer which came to my notice some time ago. This engineer was chief of an isolated plant of some 300 hp. in a moderate-sized store building in a large Western city. Plans were under way to more than double the size of the building and at the same time to erect a larger power plant in a new location to take care of the increased requirements. It was natural that this engineer should look forward to the new plant and the probable raise in salary.

About this time the central-station men became interested and seeing the opening went after the business in their usual aggressive manner. A consulting engineer was called in by the store management and reports were submitted from both sides. On a basis of costs the proposition was so evenly balanced that for several months the argument continued with about equal chance for settlement either way.

Of course, the consulting engineer and the central-station men went into the existing plant for data upon which to base their reports and estimate the requirements of the enlarged plant. What records had the engineer kept? Practically none. He had read the integrating watt-hour meter once a day and remembered what the peak load had been during the busy season. He had some indicator diagrams taken for the purpose of valve setting and on a few of these the engine speed and the load had been noted, but they had never been worked up to determine the indicated horsepower. At one time he had weighed the coal over a period of a few hours, but not the feed water. Outside of this there were only the monthly coal and labor bills in the office.

Investigation showed a reasonable economy, but at the same time there were a number of small losses that could have been detected if the most elemental records had been kept. Furthermore, it was not lack of ability on the part of the engineer but the attitude of "what is the use of worrying over today when tomorrow will bring a new plant." In this connection he had condemned all the old equipment and expected that a complete new installation would be made. In fact, the engines, generators, etc., were not half old enough and in far too good condition for the scrap-heap. As spare equipment in the new plant they would have kept down the investment outlay materially.

When the chief saw that everything was not "clear sailing" for him and about the time the first reports were made he took a big jump at conclusions. All that he could see was a sure fate for the isolated plant and the advent of central-station power. This did finally turn out to be the case, but not for nearly three months later. In the meantime the plant was sorely neglected with the result that a finer collection of pounding and leaks would be hard to find under one roof. It was hard to realize that a plant could deteriorate so much in so short a time. A few of the worst leaks had been smothered more or less with old rags and waste.

Taking the engineer's point of view when he decided on his own hook that the isolated plant was doomed, there were two prospects for him: first, to get a new position when the opportunity offered; and, second, to stay on the job after the change was made. In either case, what could he possibly gain by following the course he did? His employer could not consider him a fit man for continued employment, and could not honestly give him a strong recommendation to others.

⁂

The Electrical Conductivity of copper depends upon the total amount of impurities and not upon any one element. That is why the conductivity test is so valuable in determining the purity of copper. The aggregate of all impurities is shown and thus the purity of the copper indicated. Amounts of impurities that will defy detection, or would never be known to exist by chemical analysis are found when the electrical conductivity test is applied. It can be considered one of the most valuable tests known in metallurgy.—"The Brass World."

Recent Court Decisions

Digested by A. L. H. STREET

Judicial Power Concerning Public Service Rates—Although a court has power to enjoin enforcement of an ordinance which fixes rates to be charged by a public service corporation so low that they are unreasonable and confiscatory, it is not authorized to fix a reasonable rate, according to the decision of the United States District Court for the Northern District of California, in the case of Pacific Gas & Electric Co. vs. City & County of San Francisco, 211 "Federal Reporter," 202.

Power as Part of Public Improvement—In holding that a public ditch contractor's bond to pay for all "material furnished" under a contract for the construction of a drain secures payment for fuel used in the work, the Minnesota Supreme Court recently said:

> Power must usually be generated in ditching and we think liability should not be restricted to items actually entering into the completed structure. It is sufficient if the materials be reasonably incident to the performance of the particular contract. (Fay vs. Banker's Surety Co., 146 "Northwestern Reporter," 359.)

Stringing Electric Power Wires near Telephone Lines—It is actionable negligence for a company to string uninsulated high-tension wires within 18 in. above telephone wires, if a telephone lineman is injured through coming in contact with one of them, while in the performance of his duties, and in the exercise of due care for his own safety. Since he has no contractural relations with the electric company, he cannot be deemed to assume the risk of such an accident. (Michigan Supreme Court, Teachout vs. Grand Rapids, G. H. & M. Ry. Co., 146 "Northwestern Reporter,"

Responsibility for Defective Steam Valve—In a recent suit brought to recover damages for death of an engineer in an industrial power plant, caused by the coming off of a bonnet on a steam valve, allowing steam to escape, the Massachusetts Supreme Judicial Court sustained the right to recover on the grounds that decedent did not assume the risk of such an accident, and was not guilty of contributory negligence, and that the employer was negligent in failing to discover and remedy the defective condition. Incidentally, the court finds that the testimony of a state boiler inspector that he would not have gone into the boiler room and attempted to move certain bolts on the valve, if there were 80 lb. of steam on the boiler, even if he was in a "four-acre lot and could run away," was properly excluded. The court says: "It was immaterial what Sullivan would have done, and yet more immaterial what he might have said that he would have done." (Loftus vs. Fall River Laundry Co., 104 "Northwestern Reporter," 575.)

Liability for Boiler Explosion—These facts were held by the Pennsylvania Supreme Court in the recent case of Hitchman vs. H. S. Kerbaugh, Inc., 89 "Atlantic Reporter" 669, to be insufficient to establish liability of the defendant company for fatal injury to an employee, caused by the explosion of a boiler used in construction work. There was no evidence to show how long the defendant had owned the boiler, if the company owned it at all; nor how long the boiler had been used; nor that the company had failed to make proper inspection of it. The proof was just as consistent with the defendant's theory that the accident occurred through the decedent's failure to keep the boiler supplied with water, as with the plaintiff's theory of negligence attributable to the company. The evidence showed that the parts which were claimed to have been defective were intact after the explosion, and that the part that blew out was in close proximity to the point where danger would result if water were suddenly turned on after permitting it to run too low. The court further finds that the plaintiff was not entitled to show that, when found in a dying condition, decedent said that he did not know how the accident happened, that he "had plenty of water and plenty of steam," that statement amounting to a mere conclusion.

Liability Concerning Electric Wires—The appellate courts of the country are called upon every month to reaffirm the liability of electric companies for injuries to persons accidentally coming in contact with high voltage. Among the latest cases on this subject are McCrea vs. Beverly Gas & Electric Co., 104 "Northeastern Reporter," 365; and Spencer Light, Power, Heat & Water Co., vs. Wilson, 104 "Northeastern Reporter," 94. In the first case, the Massachusetts Supreme Judicial Court holds that an electric company was guilty of actionable negligence in maintaining uninsulated high voltage wires in close proximity to trees which it was known to be necessary for municipal employees to climb in performing certain duties. In the other case the Indiana Appellate Court decided that an electric company which negligently permitted high-voltage wires to remain near a rotten telephone pole in such position that when the pole fell over it broke one of the wires, which was thus permitted to come in contact with a nearby wire clothes line, is liable for injury to one who attempted to use the clothes line, although the company cannot be presumed to have foreseen the particular accident. The court says:

> It has long been settled law that when one conveys through the streets and alleys of a municipality a substance which is known to be as dangerous as electricity, he is charged with exercise of the highest degree of care to see that it does not escape so as to injure life or property.

Water Power Rights Subject to Condemnation—The right of a city, in providing a water supply for its inhabitants, to condemn water rights previously acquired by a water power company is recognized by the United States District Court for the Northern District of Ohio, in the case of Cuyahoga River Power Co. vs. City of Akron, 210 "Federal Reporter," 524. But it is also held that the city is not entitled to condemn any such rights without first paying due compensation therefor. On this important question, the court says:

> The plaintiff is a private hydro-electric corporation organized under the general laws of Ohio; having been granted its charter it had the right to be a corporation; and, except so far as limited by law, it had the right to proceed, as it saw fit, by appropriation or otherwise, with the accomplishment of the purposes which it has itself declared. It is not by virtue of its incorporation or of its franchise bound to carry out its scheme of development. A large number of cases have been cited in support of the doctrines that, by virtue of its adoption of plans, the company has thereby acquired a right to appropriate the property of others included in this plan, and that this right has thereby acquired a priority over all others, except the state acting directly upon this property. This might be true as between private corporations; but as between a private corporation vested with the right of eminent domain for the carrying out of the purposes of a quasi public nature and the subdivision of a sovereign state, like a municipal corporation, which exercises the power of eminent domain to carry on the vital needs of its population for a supply of water for domestic purposes, this priority cannot exist. The municipality is given a paramount right to appropriate property needed for that purpose, although the same property has become the subject of earlier appropriation proceedings by a private corporation.

Incidentally, the court concludes that the decision of the municipal authorities as to the actual necessity for appropriating the waters of the stream for municipal purposes cannot be disturbed by the courts, in the absence of a showing of bad faith in the matter.

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A Municipal Electric Plant in Trouble

There was much local discussion in connection with the municipal electric-light plant of Kansas City, Kan., which failed to furnish the customary "juice" for several nights during the latter part of February. From the daily press it appears that the interior of the turbines became incrusted with a scale from impurities carried over by the steam from the boilers. An attitude of suspicion and suggestions of vandalism were indulged in freely.

A contributor assures us, however, that the conditions were not in any way unusual or necessarily involved beyond keeping the boilers clean, or better yet, purifying the feed water coupled with frequent inspection of the machines.

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Oil-Engine Flywheel Explodes

On May 13, the flywheel of a 30-hp. horizontal crude-oil engine at the works of the Carbo Steel Post Co., in Chicago Heights, Ill., burst into a dozen pieces, killing one man instantly and slightly injuring another.

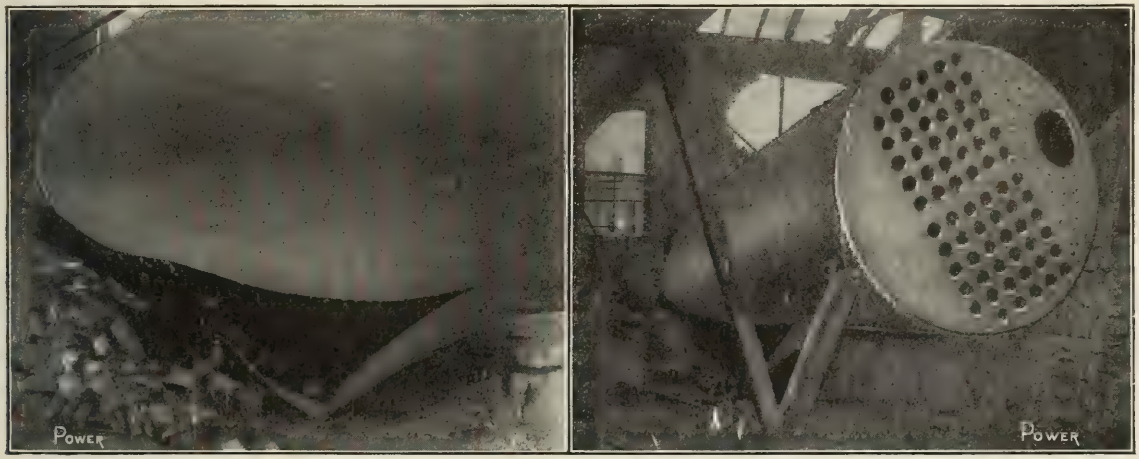
Since its installation three months ago, the engine had been run day and night, driving by belt a small generator furnishing current for galvanizing purposes and also a line shaft for general power purposes. The engine cylinder was about 9x14 in. The flywheel was 5 ft. in diameter, weighing 1500 lb., and as the speed of the engine was 250 r.p.m., the peripheral velocity would be 3927 ft. per min. The rim was 8 in. wide, 1¾ in. thick at the edge and the webb 4½ in. deep. It was supported by six spokes.

At three o'clock in the morning, when the accident happened, the engine was running along smoothly and without any apparent cause the flywheel suddenly let go. With the exception of a couple of small blowholes in the rim, there did not appear to be any defects in the metal. The cause was not apparent, and it is only a surmise that the blowholes weakened a wheel which was light for the service, sufficiently to cause the accident.

A Return-Tubular Boiler Explosion

The photographs reproduced are intended to show the extent of a fire-sheet failure in a return-tubular boiler at the Bellevue, Ohio, electric-light plant several weeks ago. The boiler was rated at 125 hp., and carried 100-lb. pressure.

Our correspondent stated that "a close examination along the line of rupture showed a flaw (evidently an old one) in the material from the inside about half through the thickness of the sheet. In my opinion the flaw was so situated that an inspection could not disclose it even if it had been possible to get into the boiler below the tubes. There are no evidences of lack of water, no blisters, bags or indications of overheating. The cause was, I believe, structural weakness of the sheet."



Showing the Extent of the Rupture

Two lives were lost, as well as considerable property, as a result of this accident.

Explosion Aboard the "Jefferson"

Late in the night of May 11, as the steamer "Jefferson" of the Old Dominion Line was off Cape Henry, the top afterside of the back sheet of the after starboard boiler (Scotch marine) gave way. The normal pressure is 190 lb. Eleven men are dead as the result of the accident: William L. Portlock, of Brooklyn, chief engineer; H. B. Smith, first assistant engineer; four firemen, three coalpassers, one oiler and one water tender. Mr. Portlock had been in the company's service for more than thirty years. The vessel was towed into Norfolk by a wrecking tug.

In the boiler room are eight Scotch marine boilers. The firing aisle is about 40 ft. long and less than 15 ft. wide. There are but two exits, one a small doorway aft into the engine room, the other an iron ladder at the forward end. The injured boiler is the first to the right (or starboard) as one stands in the small doorway connecting the engine and boiler rooms. The boilers were built in 1899 and put into the "Jefferson" when new; the tubes are 3½ in. in diameter.

Although 190 lb. is the pressure usually carried, it is probable that at the time of the accident it was about 160 lb. as the ashes were being taken out and the pressure aboard this ship invariably dropped 30 lb. during their removal.

The tube sheet that let go did not tear away at the combustion chamber, but completely away from twelve tubes, forming a belly in the sheet. The sheet has a belly covering the area occupied by twenty-four tubes, the remaining twelve being only partly pulled away. The boilers are set athwartship—at right angles with the length of the ship. That the tube sheet was not badly burned is indicated by the fact that the belly was driven back with jacks and the sheet straightened preparatory to putting in some new tubes. The crown sheet sagged, indicating low water.

The "Jefferson" was taken out of service the first of the year and was undergoing repairs for six weeks. During that time eight new furnaces and ninety new tubes were put in, the boilers receiving an inspection at the time by the Government inspectors.

Nearly all of those who died dropped on the slippery iron engine-room floor just outside the boiler room. Two or three made their way to the main deck, where the officers and passengers had difficulty in restraining them from jumping overboard, so maddened were they by their burns. One fireman crawled into the bilge hoping to relieve his suffering by lying in the water. He died, the body not being found until the vessel reached New York.

The chief and the first assistant hastily made their way to the boiler room when the explosion occurred, hoping to save the injured. They were overcome and so severely burned that the assistant died two days later and the chief one week afterward, so that all of those in the boiler and engine rooms at the time have met their death.

Los Angeles for Municipal Ownership

The electors of Los Angeles, Calif., by a vote of 56,199 to 23,179, on May 8 authorized the issuance of $6,500,000 of bonds for the completion of a hydroelectric generating station and for building or taking over an electric distribution system.

The City Council refused to permit the question to go upon the ballot in a segregated form, namely, $1,250,000 for the completion of the generating station, upon which $3,500,000 has already been expended, and $5,250,000 for a distribution system. The three electric companies in Los Angeles offered to buy the energy produced at the aqueduct plant at a price to be fixed by the state railroad commission, the city to fix the price at which the energy would be resold to consumers, but the offer was rejected.

It is reported that the intention of the city's administration is to acquire a distributing system by eminent-domain proceedings. It is believed that these proceedings will be contested to the limit.

Plan to Centralize London's Electricity Supply

The centralization of the electricity supply for London, England, has been recommended in a recent report to a special committee of the London County Council by C. H. Merz and W. McLellan, consulting engineers. They point out that the present position of the supply services is unsatisfactory as the result of a Parliamentary policy of encouraging the formation of numerous small competitive undertakings. After studying the amount and variety of the future demands of the whole metropolitan area, these engineers estimate the output needed in the near future at twenty times the present. They do not consider the enlargement of any of the existing stations in this district economical or desirable.

Messrs. Merz and McLellan recommended instead a concentration of a number of large generating stations on neighboring sites, 10 or 12 miles down the Thames. This would be under a new organization amalgamating all the old undertakings. Power would be distributed over the existing networks where possible and elsewhere supplemented by a new three-phase network; there would also be standardized a high voltage, three-phase, 50-cycle, primary distribution system. The immediate outlay required is estimated at some $35,000,000. The annual saving over the development of existing plant is estimated at $850,000.

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Meeting of Chicago Section A. S. M. E.

"Machine Shop and Machine Tool Practice" was the topic for discussion at the last meeting of the season for the Chicago section of the American Society of Mechanical Engineers, held in the Crystal room of the Hotel Sherman on the evening of May 13. Fully 150 were at table and all were enthusiastic over the distinguished list of sqeakers, which included James Hartness, president of the society; Calvin W. Rice, secretary; Dean Goss, of the University of Illinois; Robert W. Hunt, P. W. Gates and A. M. Houser.

Chairman Bird officiated and made a few introductory remarks on the work of the local committee. The organization was only a child two years old. The committee at first did not know what was wanted, and it was not until the last of the five meetings held last year that the section really found itself. This was a dinner meeting, and it was the first at which good fellowship appeared. This plan was continued, and no doubt has been largely responsible for the decided success of the meetings this season. Two things have been kept in mind: sociability and the best speakers that could be found.

Secretary Naylor spoke briefly on money matters, after which the following officers were elected for the ensuing year: Samuel G. Neiler, Rich & Co., consulting engineers, chairman; H. M. Byllesby, president of H. M. Byllesby & Co., vice-chairman; H. M. Montgomery, Permutit Co., secretary and treasurer; P. A. Poppenhusen, president of the Green Engineering Co., and H. S. Philbrick, professor of mechanical engineering at Northwestern University, other members of the committee.

Dean Goss stated that the engineer more than at any previous time is a conspicuous figure. His influence is broadening and reaching out into all walks of life. To develop the engineer must affiliate with other members of the profession. It is worth while for one who is trying to do something to have good help by his side. He was delighted with the good work being done by the Chicago section and asked for an expression of appreciation of the executive committee. As to the topic of the evening it was his thought that the development of the machine tool typified the development of engineering progress. On the trip abroad he was impressed with this fact. At some of the largest works the management would say: "Here they are! We have got them!" as though attributing their greatness to the American machine tool.

President Hartness brought the greetings of the national body to the Chicago section. All at the home office have the Chicago section in mind, and it is their desire to keep in closer touch with the local organizations. It was his hope that the section would build up to greater proportions and that more of the members would be seen at the national gatherings. In his preliminary remarks President Hartness spoke of the advantages of getting together; it helps in engineering work, and the engineer cannot work as a hermit. Evenings such as this are fruitful in inspirations which aid in doing better work. Success comes from contact and without it mediocre results are to be expected. The speaker emphasized the need of specialization and of knowing more than straight engineering work. Primarily, the engineer is a director of men and must know his fellow creature. If he fails to learn how he can work most efficiently, he is missing much. The human being is a creature of habit and works most efficiently along habit lines. The more we can do to allow him to work along these lines, the more we are doing for our fellowman and for the general advancement of the profession.

A. M. Houser, mechanical engineer of the Crane Co., presented a short paper on "Designing the Product." Too little attention had been given to this subject. The master mind in a flash of genius might invent a machine or a particular piece of apparatus but improvement requires hard work and close attention to details. Standardization was of great importance and simple systems of working for each department. It was his opinion that a general system should be developed covering all engineering office work. It was just as important as for any other department. With such a system in force, the engineer in passing from one company to another, need spend but little time in learning the details of the business. It was gratifying to the speaker to announce that one standard for flanged fittings had finally been agreed upon and that the matter was to come before the spring meeting. The standard for pipe threads was also mentioned, and, besides, a standard for gate valves which had recently been adopted by the underwriters.

P. W. Gates spoke of the early days of machine-shop practice, including a mention of the first die used for cutting a pipe thread, Chicago's first locomotive, some old-time steam hammers and other interesting examples of the work done in the early days.

A few extemporaneous remarks by Capt. R. W. Hunt left the gathering in a happy frame of mind to listen to the home secretary, Calvin W. Rice, who had come all the way from New York for the meeting. His catchword was the human side. The Chicago section had developed it and that was the reason for its success. Participation of members holds the interest and informal gatherings get the men to their feet. The Chicago section has a great opportunity as the home city is destined to be the largest on the continent. It has the chance to put the society in a position it does not occupy today. The local organizations have proved to be the life of the society and are what is making it worth while. There are now 12 or 14 places in which meetings are held regularly, and as soon as conditions warrant the number will be increased. Mr. Rice went into detail on the work at the home office and assured his listeners that if help were needed they would find him at the other end of the wire.

BOOKS RECEIVED

COMPRESSED AIR. By Theodore Simons. McGraw-Hill Book Co., New York. Cloth; 167 pages, 5¾x9 in.; 42 illustrations; tables. Price, $1.50.

ELECTRIC LIGHT ACCOUNTS. By H. M. Edwards. McGraw-Hill Book Co., New York. Leather; 172 pages, 4¾x7¼ in. Price, $2.

HYDRAULICS. By Ernest H. Sprague. Scott, Greenwood & Son, London, England. American agents, D. Van Nostrand Co., New York. Cloth; 184 pages, 4½x7¼ in.; 89 illustrations; tables. Price, $1.25.

STEAM TURBINES. By James A. Moyer. John Wiley & Sons, Inc., New York. Second edition. Cloth; 376 pages, 6x9¼ in.; 225 illustrations; entropy total heat chart. Price, $3.50.

STEAM PIPES. The Vulcan Boiler & General Insurance Co., Ltd., Manchester, England. Cloth and paper; 120 pages, 5¼x8¼ in.; 62 illustrations. Price, one shilling.

ENGINEERING AFFAIRS

The annual convention of the Special Libraries Association, affiliated with the American Library Association, will be held in Washington, D. C., on May 27 and 28. This association is chiefly composed of the business libraries with engineering, commercial, industrial and financial interests.

A meeting of the Engineers' Club of Cincinnati was held in the Literary Club Rooms Thursday, April 23, at which the following papers were presented. "The Beginning and Growth of the Machine Tool Industry in Cincinnati," by A. Lewis Jenkins; "Material and Construction in Local Reinforced Concrete Work," by Ludwig Eid. A paper on "Recent Development in Smoke Abatement," by A. G. Hall, was postponed to a later meeting.

Announcement has been made of the Oil Mill Superintendents' Convention to be held in Columbia, S. C., June 2, 3, 4 and 5. Headquarters will be at the Jefferson Hotel, and the exhibits and meetings will be held at the fair grounds, about two miles from the city. Special attention is called to the exhibit of machinery, since it will be of as much interest to power plant engineers and owners as to oil mill superintendents. Some of the largest makers of valves, fittings, pipe, belts, lubricants and other power plant equipment will be among the exhibitors. This will be the first exhibition of power plant equipment at these conventions, and operating engineers are invited to avail themselves of this opportunity.

The midsummer meeting of the American Society of Heating and Ventilating Engineers will be held in Cleveland, Ohio, July 9-11. Headquarters will be at the Hotel Statler. One of the features of the meeting will be an all-day trip on one of the large Lake Erie steamers, with a professional session held on board, followed by a dinner in the evening and other entertainment. In addition to the usual number of papers, the program for the meeting will include interesting committee reports on car ventilation, radiator location, special fan application, elimination of noise, chimneys and draft, industrial building installations. The Cleveland committee which is making the local arrangements for the meeting, is composed of Frank G. Thegley, 706 Rose Building, chairman; J. H. Bacon, Jr., W. M. Kingsbury, R. S. Mayer and F. H. Valentine.

Over 400 men of the various scientific and engineering societies united in a mass meeting and smoker on the roof garden of the Continental Hotel in Philadelphia, Friday evening, May 15. J. A. Vogleson, chief of the Bureau of Health, acted as toastmaster, and the address of welcome was made by Hon. George W. Norris, Director of Wharves, Docks and Ferries. The other speakers were Dr. W. W. Keen, president of the American Philosophical Society, who spoke on scientific societies; Dr. Walton Clark, president of the Franklin Institute, whose subject was "The Franklin Institute and the State," and Dr. Alexander C. Humphreys, president of Stevens Institute of Technology, who, in discussing "The Engineer as a Factor in Modern Progress," found the opportunity to voice again his plea for engineers on Public Service Commissions.

The Brooklyn Edison Co. has opened its new athletic field for the Brooklyn Edison Employees' Association, which numbers more than two thousand. It is known as the West End Oval, and is located on the water's edge. Experts regard it as one of the best equipped athletic parks in the city. The grounds can be reached direct from the company's headquarters in Pearl St. in 25 minutes. The diamond is dirt, with a grass outfield. The stands will accommodate more than three thousand spectators.

W. F. Wells, vice-president, and P. R. Atkinson, treasurer, are both greatly interested in the field, and it was largely through their efforts that the new athletic grounds were made possible. Mr. Wells, in speaking of the new field, said: "I feel certain that the grounds will be a great boon to the employees of the company. The field will furnish them with an excellent opportunity to get out in the open air after business hours. It is one of the best in the city and can be reached for one fare from all parts of the borough. This should be an inducement in itself to stimulate interest in bringing out the members of the association every Saturday. Improvements are to be made as the season advances, and I feel certain that it will be a great athletic year." A hotel adjoining the grounds furnishes opportunity for dancing. Bathing may be enjoyed by members of the association, as there are bath houses adjoining the park.

The athletic committee is W. T. Fairbairn, chairman; P. D. Sharkey, H. P. Wood, J. C. Van Duyne, E. W. Babcock, C. E. Butz and W. Eichert.

PERSONALS

William O'Hallaren, chief engineer and chief electrician of the Newmarket (Ont.) Municipal Electric Light & Water-Works, has tendered his resignation after 17 years of service.

Arthur Cushing has been appointed operating engineer of the Clinton (Ill.) Gas & Electric Co. He was formerly with the Decatur Railway & Light Co. and other Illinois Traction properties.

H. M. Wall, who for the past year has been connected with the Memphis Street Railway Co. as assistant chief engineer of power stations, has become associated with the firm of Ruebel & Wells, consulting mechanical-electrical engineers, Chemical Building, St. Louis, Mo.

Foster Hannaford has been appointed acting general superintendent of the Galesburg Ry., Lighting & Power Co., Galesburg, Ill., vice Mr. Dickerson McAfee, now on a leave of absence. Mr. Hannaford has been operating engineer of the company, which is one of the subsidiaries of the Illinois Traction System.

OBITUARY

MARTIN DELANEY

On May 10, Martin Delaney, an engineer in the plant of the Wilkes-Barre Co., Wilkes-Barre, Penn., died as the result of injuries sustained by a fall from a ladder into a 14-ft. pit. Mr. Delaney was 35 years old, and for nine years was in the employ of the Wilkes-Barre Co., the officials of which speak highly of his services. He leaves a widow and two children.

WILLIAM F CRANE

William Franklin Crane, member of the family known all over the country as engineers, died on May 18 from heart disease after a three-years' illness, at his home, 260 East 19th St., Flatbush, New York City. He was a nephew of the late Archie Crane, the Chicago iron magnate, who died last winter. Mr. Crane was born in Chicago 55 years ago, a son of the late Franklin Crane. His father was one of the three Crane brothers who founded the Crane Co., and in early life he joined the company, and came to New York to manage the Eastern business of the firm. Some ten years ago he went in the same business for himself with offices in the Singer Building. He was until recently a member of the Long Island Automobile and other clubs, but because of ill health had resigned. He is survived by a widow, who was Miss Mary Carter, of St. Joseph, Mo. Interment will be made at Chicago.

JOHN J. C. SMITH

John J. C. Smith, inventor of machinery for making insulated wires and compression castings, died at his home in Passaic, N. J., on May 11. He was 79 years old. Born in Bavaria, he came to America with his parents when still a boy, passing the greater part of his early life in Boston. In 1883 he came to Passaic and later founded the Okonite Co. One of his patents for making dies for coins and stamps was bought many years ago by the Government and is still being used in the Mint.

Mr. Smith was associated with leading American capitalists, manufacturers and inventors through his inventions, among them being Thomas A. Edison in his early days and Alexander Graham Bell, inventor of the telephone. He was instrumental in forming the first telephone company in America.

He leaves nine children

JOHN ERWOOD

John Erwood, consulting mechanical engineer and inventor, died at his home in Chicago, Ill., on Apr. 14, at the age of 54.

Mr. Erwood was born in London, England, and came to this country at the age of 20. He worked diligently in New York City for a few years, then went to Chicago, where he established himself as a consulting engineer, engaging in an active and successful career until his death.

Twenty-five years ago Mr. Erwood became consulting engineer for the Gormully & Jeffery Co., Chicago, which later merged into the Thomas B. Jeffery Co., Kenosha, Wis. The complete factory which this company occupies has a floor area of 500,000 sq.ft. and was designed and built by Mr. Erwood. The power plant, having about 4000 hp., was installed by him as well as the complete heating system and other plant details.

Mr. Erwood not only attained success as a consulting engineer, but distinguished himself as an inventor. His most notable achievement was his invention of the Erwood double-acting nonreturn steam valve, now manufactured by the Crane Co., Chicago, and known as the Crane-Erwood nonreturn valve. Another invention was the Erwood swing gate valve, manufactured by the Nelson Valve Co., Pittsburgh, and known as the Nelson-Erwood swing gate valve. Mr. Erwood was also the patentee of a blowoff valve, a noncorrosive fire-door and a water-tube boiler.

Kindness, honesty and charity were conspicuous phases of the character of John Erwood, for his heart was big and he gave with a free hand. He leaves a widow and five children.

Cause of Stay-Bolt Failures—The service which a stay-bolt is called upon to perform is a trying one. The most prolific cause for stay-bolt failures is to be found in the repeated bending stresses set up by the unequal expansion of the sheets which they support. A tough, ductile material has been found to be best suited to this service, even if toughness is secured at the expense of tensile strength.—"The Locomotive."

BUSINESS ITEMS

Newton L. Schloss, mechanical and electrical expert, has removed his office to 25 West 32d St., New York.

The Magnolia Metal Co., 112 Bank St., New York, is sending out an interesting war map of Mexico, 14½x11 in., free of charge upon application while the supply lasts.

Charles Enderle, formerly with the Harrisburg Foundry & Machine Co., is now associated with I. Copleston, Inc., 39 Cortlandt St., New York, selling exclusively the Ball engine of Erie, Penn.

The series of gas-engine data cards put out by the Bruce-Macbeth Engine Co., Cleveland, will be found extremely useful by any engineer. These cards are in the form of actual blueprints, and give really valuable data on the operation, construction and design of gas engines. Until the supply is exhausted, this series of cards may be obtained without cost by writing the Bruce-Macbeth Engine Co., 2107 Center St., N. W., Cleveland.

At the annual meeting of the stockholders of the Joseph Dixon Crucible Co., held at the company's main office in Jersey City, N. J., on Monday, Apr. 20, 1914, the retiring Board of Directors, consisting of Geo. T. Smith, William Murray, George E. Long, Edward L. Young, William G. Bumsted, J. H. Schermerhorn and Harry Dailey, were unanimously reëlected. The officers of the company, consisting of George T. Smith, president; George E. Long, vice-president; J. H. Schermerhorn, treasurer; Harry Dailey, Secretary, and Albert Norris, assistant treasurer and assistant secretary, were also reëlected.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Bangor Ry. & Electric Light Co., Bangor, Maine, contemplates extending its system. New waterwheels and generators, costing $28,500, will be installed at the Veazie power station.

The Union Knitting Mills, Pottsville, Penn., contemplate installing an electric-power plant. J. I. Reed is the owner.

SOUTHERN STATES

It is reported that the Mountain Milling Co., White Sulphur Springs, W. Va., will remodel its electric-light plant and install new equipment.

The Center Falls Power Co., Center Falls, N. C., will erect a plant. J. B. McCrary Co., Atlanta, Ga., has been engaged to take charge of the work.

The Tatum Bros. Real Estate & Investment Co., Miami, Fla., contemplates constructing a power plant.

The Lebanon Milling Co., Lebanon, Ky., is in the market for motors. The company is equipping a plant for the manufacture of flour.

The City of Louisville, Ky., will install boilers for the heating plants of the Boys' High School, estimated to cost $300,000, Ward & Glossop, Joseph & Joseph, and John B. Hutchings Schools, estimated cost, $100,000 each.

The Harlan Coal Mining Co., Louisville, Ky., which is equipping a new operation at Coxton, Ky., is buying power equipment through Frank Sneed, general manager, Coxton.

CENTRAL STATES

The power and light plant of E. K. Gardner, at Shreve, Ohio, was destroyed by fire Apr. 29. Estimated loss, $10,000.

The City Council, Youngstown, Ohio, has appropriated $3000 to employ an engineer to erect a municipal electric-light plant.

The Alma Illuminating Engineering Co., Alma, Mich., will erect a power plant at Riverdale. H. S. Conner is engineer-in-charge.

The Electric Light Commission, Crystal Falls, Mich., will purchase one 200-kw., three-phase, 60-cycle, 2300-volt generator. J. H. Sanders is superintendent.

A company is being organized by the business men of Rankin, Ill., for the purpose of erecting an electric-light plant. S. Johnson is interested.

At a recent election, it was voted to erect a municipal electric-light plant at Sheldon, Ill.

The Spring Valley Gas & Electric Co., Spring Valley, Ill., will install a 300-kw. generator.

The power plant and mill of the Bark River Electric Light & Power Co., and the Rome Roller Mills Co., Rome, Wis., were recently destroyed by fire. Estimated loss, $25,000.

WEST OF THE MISSISSIPPI

The City Council of Valley Falls, Kan., will buy new engines and generators for the municipal light plant.

The electric-light committee, Glasgow, Mont., will purchase one 50-kw., three-phase, 50-cycle, 2300-volt generator and some additional equipment. A. J. Melvin is superintendent.

The electric-light plant at the State Agricultural College, Jonesboro, Ark., which was recently destroyed by fire, will be rebuilt.

The city of Tucson, Ariz., contemplates purchasing two water-tube boilers for the water-works system, to cost about $8000. J. Moss Ruthrauff is city engineer.

The power plant of the Eastern Oregon Light & Power Co., at Baker, Ore. was recently destroyed by fire. Estimated loss, $75,000.

The Anaheim Union Water Co. will install a 150-hp. electric motor in its plant at Fullerton, Calif.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work) and For Sale, 5 cents a word, minimum charge, $1.00 an insertion.

Miscellaneous (Educational—Books) 10 cents a word, minimum charge $1.50

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

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POSITIONS OPEN

WANTED FOR PANAMA CANAL, experienced erectors for the erection of lock machinery; salary, $140 month; free transportation from New York or New Orleans; must be American citizens (final papers), under 45 years, in sound physical condition. Write Panama Canal Office, Washington, D. C.

POSITIONS WANTED

MECHANICAL DRAFTSMAN, 13 years' experience on design and construction of steam stations, is open for engagement; 30 years of age, hustler and producer. P. W. 227, Power.

SUPERINTENDENT of power of large group of power plants, desires to correspond with employers requiring the services of a high-grade power-plant engineer; thoroughly experienced in all branches, and can deliver results; only a strictly high-grade position, and salary commensurate with same is solicited. P. W. 214, Power.

ENGINEER, technical graduate, 10 years' experience with large engines, Curtis, Parson and Rateau turbines, up to date on electrical and refrigerating machinery, formerly chief engineer in large hotel, would like to correspond with a firm where exceptional ability and low-power production is appreciated; can furnish first-class references from past and present employer. P. W. 228, Power.

WANTED

AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

MISCELLANEOUS

PATENTS. C. L. Parker, patent attorney, 904 G St., Washington, D. C. Inventor's handbook sent upon request.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

FOR SALE

ENGINE—16x36 Hewes & Phillips Corliss engine, entirely overhauled, fully guaranteed, $700. Duzets & Son, Hudson Terminal, New York.

BOILERS—Two 50-hp., 54-in. by 12-ft. return-tubular boilers, in excellent condition; will sell for $200 each f.o.b. cars Lockport, N. Y. F. S. 218, Power.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

ALTERNATOR—100 kw. General Electric revolving field, three-phase, 60-cycle, 250-volt, with exciter and switchboard, $600. Duzets & Son, Hudson Terminal, New York.

GENERATORS—75 kw. Crocker-Wheeler 250-volt generator, direct connected Harrisburg Fleming engine, with switchboard, $1200. Duzets & Son, Hudson Terminal, New York.

TURBINE GENERATING SET—300-kw. Westinghouse Parsons three-phase, 60-cycle, 220- or 440-volt turbine outfit, with condenser; practically new. George Sachsenmaier & Co., 143 North Third St., Philadelphia, Penn.

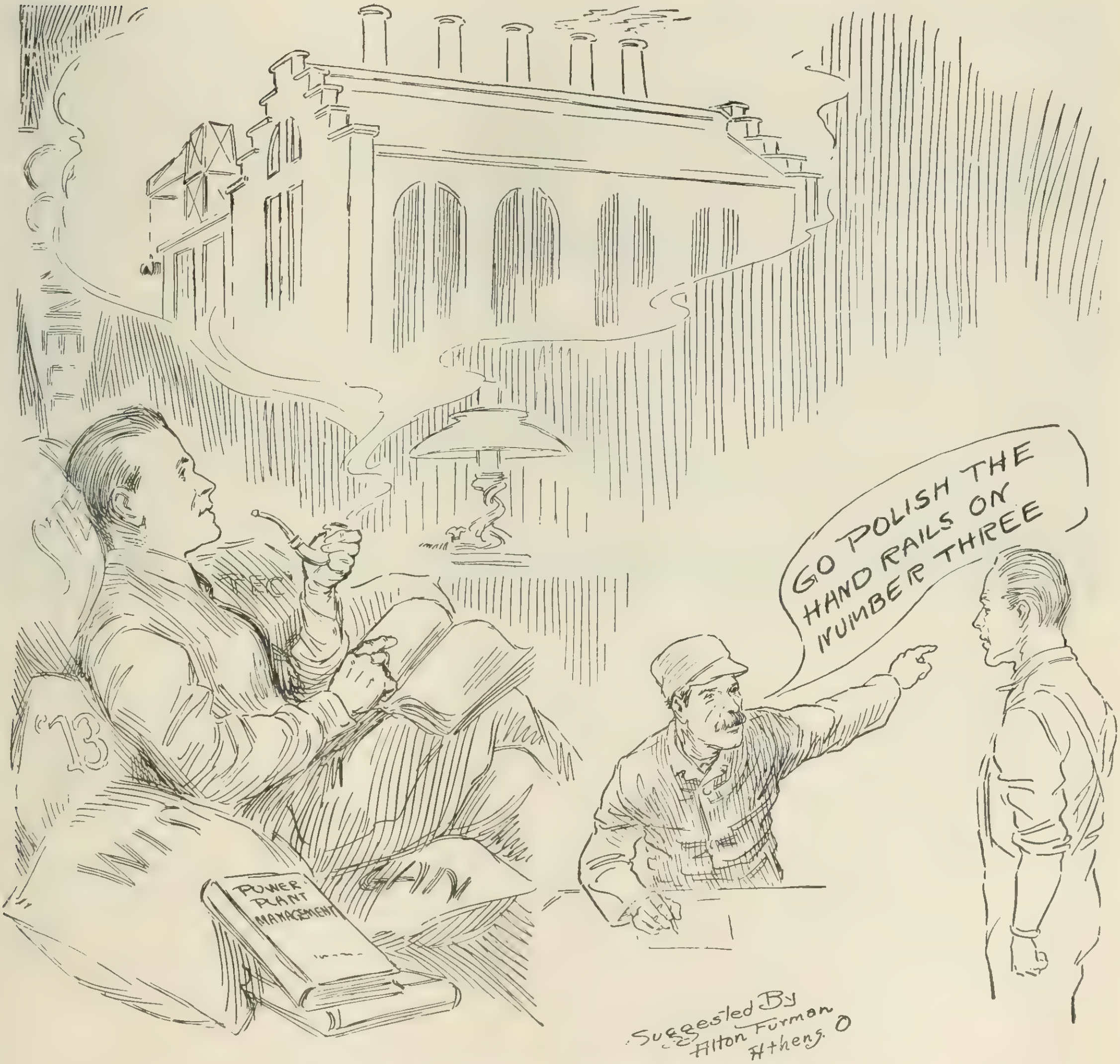
COCHRANE HEATER—One No. 3, rebuilt and in excellent condition, $95; one American steel plate blower, three-quarter housing, bottom horizontal discharge, 24-in. inlet, first-class shape, $65. The Arbuckle-Ryan Co., 224-34 Cherry St., Toledo, Ohio.

BOILERS—Battery of three 125-hp. horizontal tubular; insured 125 lb.; stack, 66 in. diameter, 90 ft. high, and breeching; manufactured by the E. Keeler Co.; cost, $3500 f.o.b. cars; will sell at bargain. McKenzie Mfg. Co., 765 North Ave., Plainfield, New Jersey.

PATENTS, PATTERNS, etc., for the simplest device for prevention of smoke on the market; this device is in successful operation; will sell outright, or on royalty basis; this device can be sold for less money and at a good profit than any other device on the market. F. S. 217, Power.

POWER

Vol. 39 NEW YORK, JUNE 2, 1914 No. 22



GO POLISH THE HAND RAILS ON NUMBER THREE
POWER PLANT MANAGEMENT
'13
Suggested By Alton Furman Athens O

THE FOOT OF THE LADDER

Westinghouse Marine Equipment

SYNOPSIS—Description of the marine steam turbine, reduction gear, bridge control and auxiliaries as built by the Westinghouse Machine Co. with special reference to the installation on the U. S. collier "Neptune."

::

In the application of steam turbines to marine service, certain problems are encountered which are not present in land practice. Among these may be mentioned the desirability of relatively low propeller speeds, whereas it is desirable to run the turbine at high speed to keep down the size and weight and to attain greater economy. This condition led to the development of the Melville-Macalpin reduction gear, which has now passed the experimental stage, and has successfully met the requirements for the transmission of large powers in actual service, the most notable installation being that of the U. S. collier "Neptune."

The results of the trials of the original equipment of this vessel, while demonstrating the adaptability of reduction gears to marine service showed the necessity of modifications of the turbine and reduction gear. One of the important points brought out by the trials was that the revolutions of the propeller were too high, the original revolutions at 14 knots being 135 and those of the turbine 1220. It was decided, therefore, to replace the propelling machinery, one of the changes being a decrease in propeller speed to 110 r.p.m. and an increase in turbine speed to 1910 r.p.m. The following description applies to the remodeled arrangement and also represents what the Westinghouse Machine Co. has developed as a complete line of equipment for marine service, including the turbine, condensers and auxiliaries, reduction gear and dynamometer, and bridge control by which the turbine is under the complete control of the navigating officer.

TURBINE

This is a combination impulse and reaction type, the high-pressure elements of both the ahead and astern turbines consisting of impulse wheels. The substitution of a high-pressure impulse wheel for reaction blading in marine turbines has two important advantages: First, it has a greater stopping torque, and, second, it permits nozzle control. Furthermore, it materially shortens the turbine and permits both the ahead and the astern turbines to be contained in one casing, thus eliminating cross-connections.

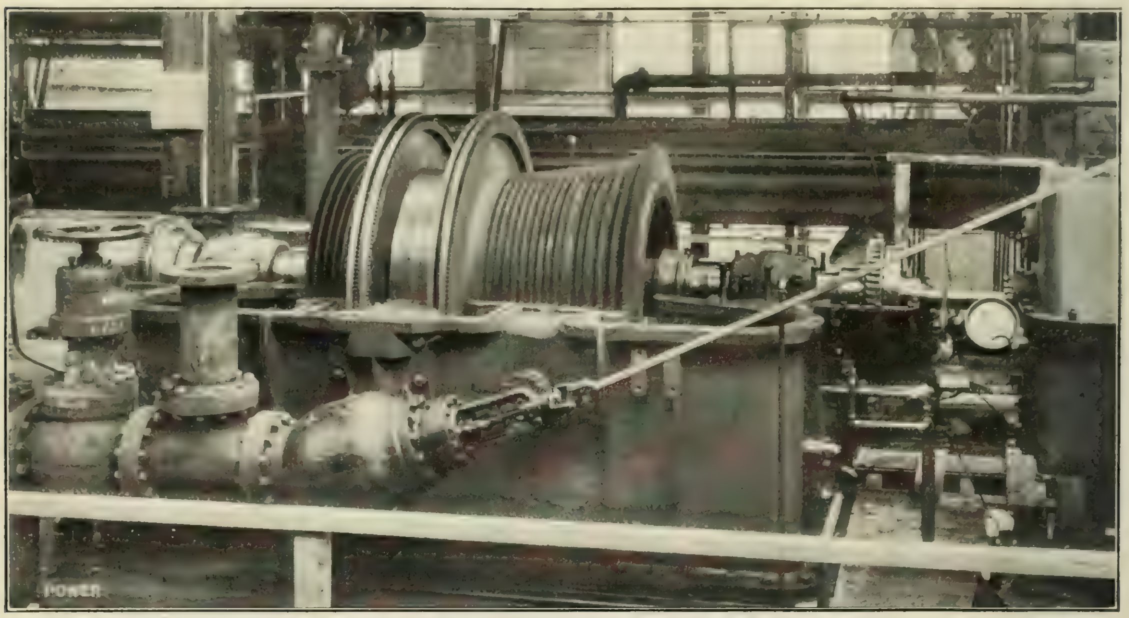


FIG. 1. TURBINE WITH CASING AND BLADE RINGS REMOVED

Although the impulse wheel is not as efficient as reaction blading, it is possible to so design an impulse wheel with two rows of blades that its efficiency will not fall off seriously when the steam velocity is only 2 to 2½ times the blade speed, and will remain nearly constant until the velocity of the steam reaches 4 to 4½ times the blade speed. Therefore, by the use of nozzle control the efficiency of the high-pressure element may be kept fairly constant over a considerable range of power and speed.

Fig. 1 shows the turbine with the stationary blade rings removed, and Fig. 2 is a section through the turbine. It will be noted that the spindle is in three parts, bolted together. The first section carries the astern impulse wheel and reaction drum, the middle section the ahead impulse wheel and part of the ahead reaction drum, and the third section the remaining part of the reaction drum. As the effective mean diameter of the ahead and astern reaction sections are the same, a single dummy located between the two impulse wheels serves for both the ahead

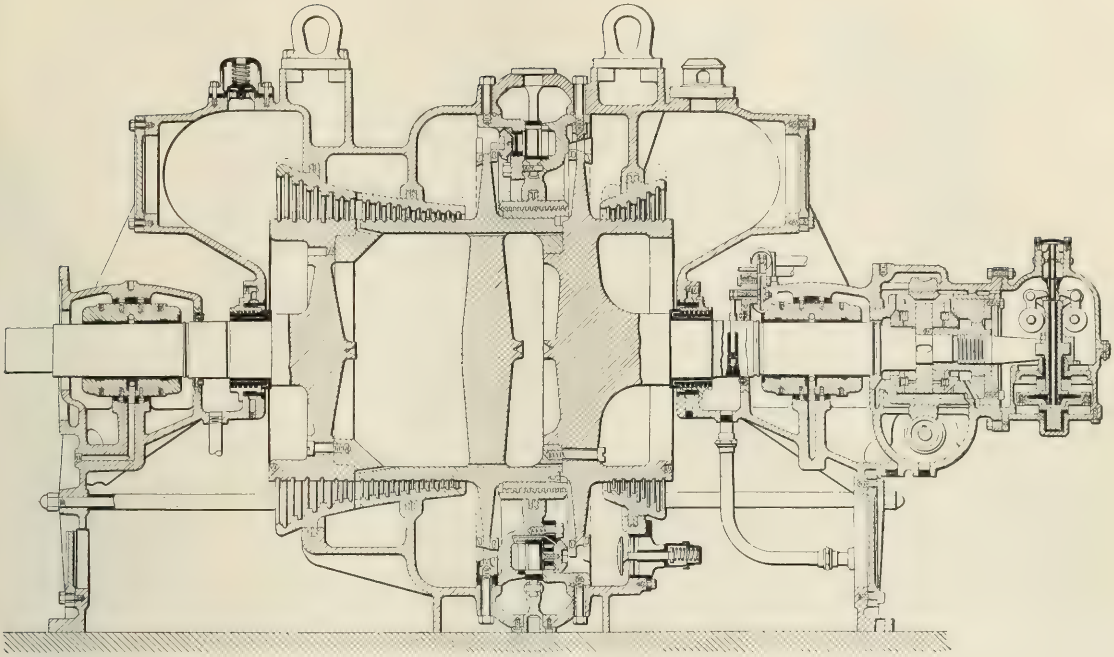


FIG. 2.

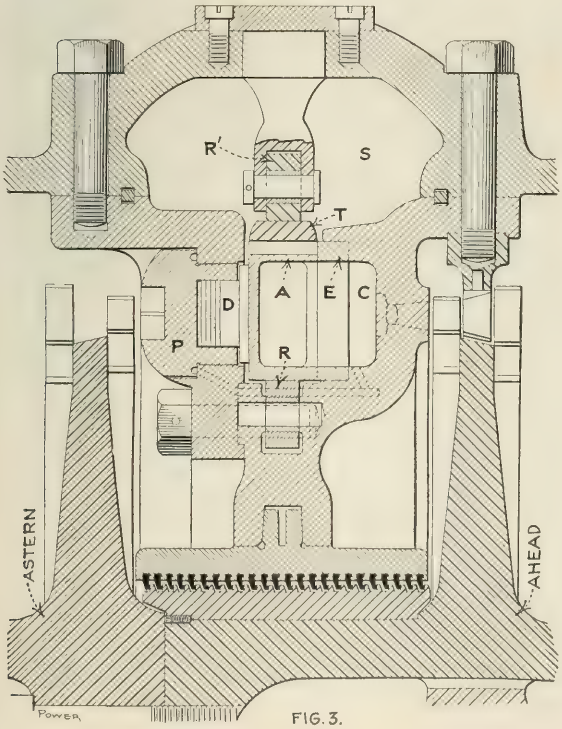


FIG. 3.

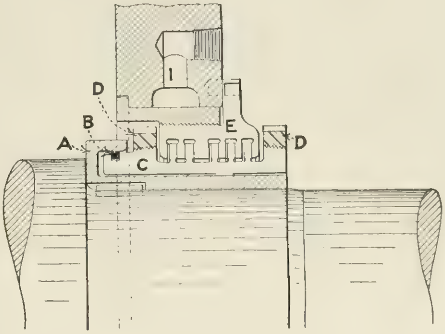


FIG. 4.

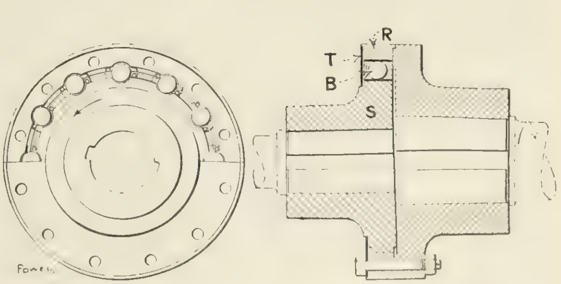


FIG. 5.

SECTION AND DETAILS OF WESTINGHOUSE MARINE TURBINE

Fig. 2. Longitudinal section through turbine. Fig. 3. Nozzle valve and nozzles. Fig. 4 Turbine glands. Fig. 5 Flexible coupling.

and the astern reaction action. Any slight unbalanced end thrust is taken up by a Kingsbury thrust bearing.

Referring to Fig. 2, the valve connecting the astern impulse-wheel chamber with the condenser is provided to permit the escape of any steam leaking past the dummy when running ahead, without the necessity of its passing through the astern reaction blading and thus causing additional lost work. This bypass valve is operated automatically by a piston resisted by the spring which normally holds the valve open, as shown, but as soon as the steam is admitted to the first astern nozzle the pressure back of the piston brings the valve to its seat.

In Fig. 3 is shown the nozzle valve and nozzles. The valve *A* is of monel metal with a cast-iron seat *E*, the balancing pistons *D* and caps *P* being of bronze. The nozzle valve *A* is moved by a rack engaging with gear teeth in the ring *T*, and rollers *R* and *R'* permit easy movement of the valve. The main steam supply for the ahead impulse wheel opens into the space *S* in the lower half of the turbine cylinder and that for the astern wheel into a similar space in the upper half.

One of the ahead nozzle blocks and the sliding valve are shown partly assembled in Fig. 6, also four of the balance pistons in place. The turbine glands are a modified type of labyrinth packing, as shown in Fig. 4, consisting of a brass sleeve *A* on the shaft in which fits a snap ring *B* packing the sleeve *C*, held by the rings *D*, and which rotates with the shaft. End movement of the sleeve *C* relative to the shaft is permitted so that the collars which fit into the bushing *E* with a few thousandths clearance will not bind nor press heavily against *E* when the spindle moves endwise from expansion. Steam for sealing and lubricating the labyrinth is supplied through the inlet *I*.

The stationary reaction blades are held in cast-steel rings doweled to the turbine cylinder, Fig. 7 showing the method of attaching the large reaction blades.

In order to permit the gear pinion to float longitudinally without imposing any end thrust on the teeth of the pinion or gear, a special flexible coupling (Fig. 5) is used. This coupling consists simply of two flanged collars, one on the turbine and one on the pinion drive shaft, and a ring *R* bolted to the part of the coupling on the turbine shaft. There is a slight clearance between the ring *R* and the hub *S*, and the driving force is transmitted through the ring to the hub by means of steel balls *B* inserted in holes drilled partly in the ring and partly in the hub. A retaining ring *T* prevents the balls from coming out.

REDUCTION GEAR

Although the principle of the Melville-Macalpin gear and its later development by George Westinghouse have been mentioned in these columns, a brief review may be in order at this time. Referring to Fig. 8, *AA* is a double-helical pinion, *BB* the driven gear and *CC* the frame carrying the pinion-shaft bearings; *DDD* are three pistons resting on suitable supports. Oil under pressure is introduced through the passage communicating with each of the pistons and causes the pinion frame *C* to float. Inasmuch as the three supporting cylinders are in communication with one another, the pinion frame is free to align itself in such a way as to bring about an even distribution of tooth pressure across the entire working face of the gear. To provide for reversed rotation, and, consequently a reversed thrust on the pinion frame, a second set of cylinders and pistons is placed on the opposite side, as may be seen in Fig. 9, which represents a cross-section through the floating pinion frame at the middle bearing. Low-pressure oil is introduced into the upper end of the central passage and through *J*, which communicates with the three shaft bearings. Assuming that the pinion is rotating in a clockwise direction, the reaction between it and the gear will cause the floating frame *L* to tilt slightly to the right, which brings the outlet to passage *F'* against the sleeve valve *K'* and seals the former. The spring in the valve *K'* provides easy contact and does away with any hammering.

Each bearing will draw oil from *J* and discharge through the opening on the right, past a ball check valve into the chamber *H'H'*, thence into the cylinders containing the supporting pistons *D'*. Since the outlet from *F'* is sealed by the valve *K'*, the oil pressure will build up, due to the pumping action of the shaft, until it just balances the side thrust of the floating frame. The instant this pressure is exceeded, the pinion frame is forced slightly to the left, causing the upper end of *F'* to become unsealed and allowing the surplus oil to escape into the gear case from whence it is returned to passage *G*. In this way the valve *K'* throttles the discharge from *F'* sufficiently to maintain the pressure constant behind the pistons *D'*. With the reverse direction of rotation the action is the same, the valve *K* and passage *F* coming into use.

The pressure of the oil is proportional to the force exerted at the pitch line of the gears. This force multiplied by the pitch-line speed in feet per minute divided by 33,000 gives the horsepower that is being transmitted. Therefore, by connecting a continuous-speed recorder and a recording pressure gage, a continuous dynamometer record may be had.

BRIDGE CONTROL

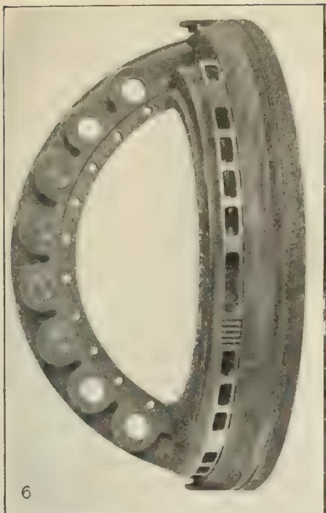
A novel feature of the "Neptune's" equipment is the bridge-control mechanism which places the propelling machinery directly under the control of the navigating officer and does away with the necessity of using the engine-room telegraph. A change can be made to the telegraph and engine-room control in a few seconds if necessary. In the preliminary trials this control was found to give entire satisfaction. Fig. 10 shows the port turbine of the "Neptune" with the oil relays, the governor being on the other end; and Fig. 11 the bridge-control stand, which is so arranged that both turbines may be controlled independently or together.

AUXILIARIES

The full line of marine auxiliaries comprises generating sets, both direct and alternating current; condensing equipment, including surface condensers, air pumps, condensate pumps and circulating pumps; high- and low-pressure centrifugal pumps and centrifugal fans. The principal characteristic of these is the use of a simple rotating element instead of many reciprocating parts.

GENERATING SETS

Direct-current generating sets with direct drive are built in sizes of from 1 to 150 kw. and with gear drive in sizes of from 50 to 500 kw., the problem of drive in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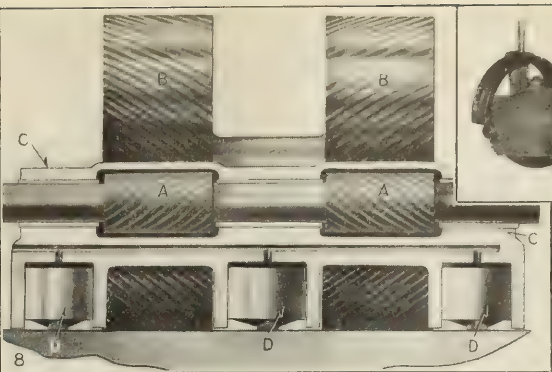

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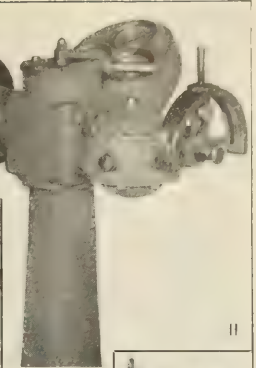
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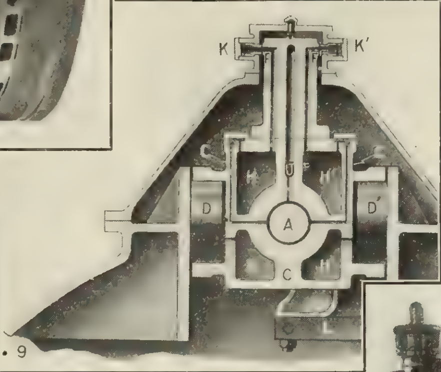

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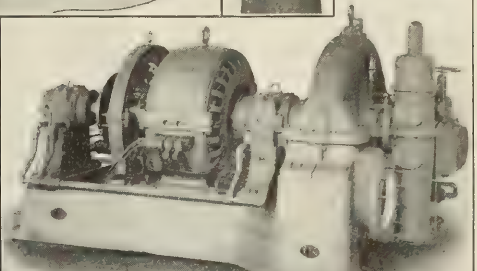
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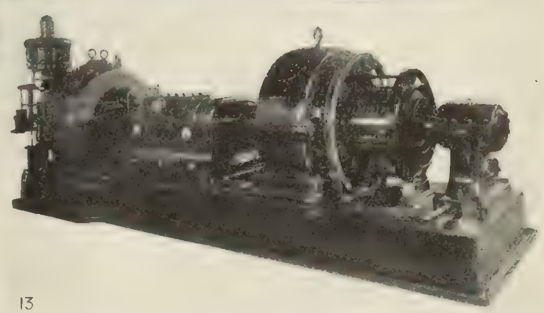
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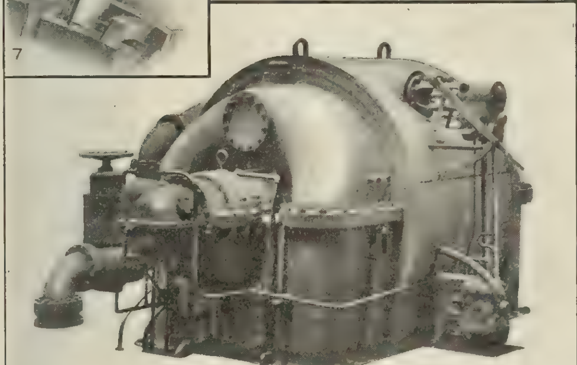
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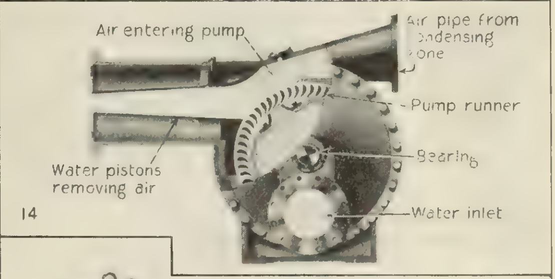

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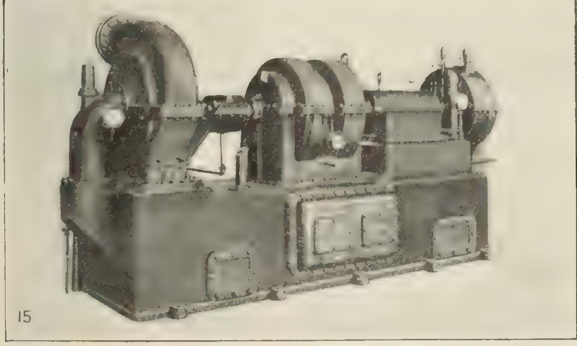
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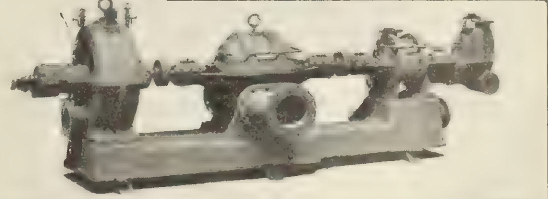
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TURBINE AND REDUCTION-GEAR DETAILS AND AUXILIARIES

Fig. 6. Nozzle block. Fig. 7. Large reaction blading. Figs. 8 and 9. Reduction gear showing floating frame. Fig. 10. Port turbine with oil relays. Fig. 11. Bridge control stand. Fig. 12. 100-kw. direct-current turbo-generator. Fig. 13. 300-kw. direct-current generator with geared turbine drive. Fig. 14. Leblanc pump. Fig. 15. Combined air and circulating pumps with geared turbine drive. Fig. 16. Combined air, condensate and circulating pumps with direct turbine drive.

the larger units being in many respects similar to that of driving a propeller. These units are furnished either condensing or noncondensing up to 150 kw., and above this, condensing only. The weights of the geared sets range from 15 to 45 lb. per horsepower.

While direct current has heretofore been used almost exclusively in marine practice, several alternating-current installations have been made recently and its further use is anticipated. Owing to the desirability of high speeds with alternating-current generators, direct drive is employed exclusively with these sets. They are also condensing and are furnished in sizes of 100 to 500 kw., 60 cycles and voltages of 125, 220 and 440.

In the small generating sets the bearings are ring lubricated, but in the 25-kw. size and above, forced lubrication is employed.

Condensing Equipment

The Westinghouse condensing plant, as shown in Fig. 17, consists of a surface condenser, a Leblanc air pump and a centrifugal circulating pump. These are furnished separately or combined on a shaft. Fig. 15 shows combined air, and circulating pumps with geared drive, and Fig. 16 combined air, condensate and circulating pumps with direct turbine drive.

The air pump is of the Leblanc type, which uses fresh water in a closed circuit, and is made in capacities from 800 to 25,000 sq.ft. of cooling surface. For the benefit of those not familiar with this type of pump, its operation may be explained briefly as follows: Referring to Fig. 14, a continuous series of rapidly moving layers of water are projected into the air chamber, condensing the vapor present and cooling and concentrating the air which is imprisoned between the pistons or vanes and carried out through the discharge nozzle, during which process it is compressed to atmospheric pressure. The water pistons have no clearances and there are no reverses; consequently no losses due to these causes.

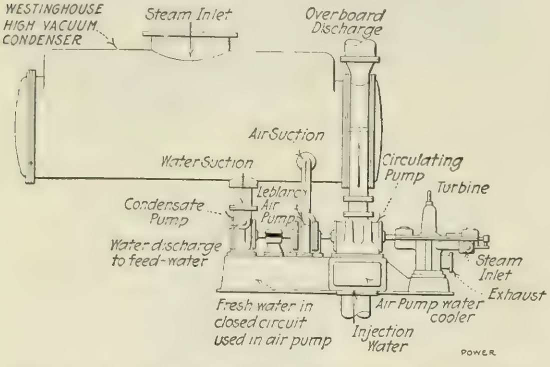


Fig. 17. Westinghouse Marine Condensing Plant

The condensate pump is a single-stage, double-inlet runner, horizontal type, although for naval use a special vertical type with single-inlet runner is supplied.

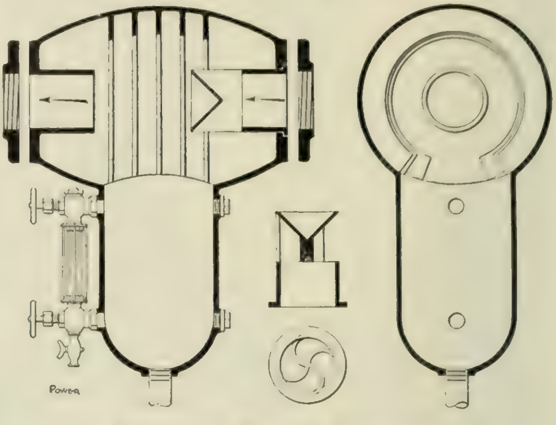
Either a single or double runner, double-inlet centrifugal pump is used for circulating, in capacities of from 400 to 40,000 gal. per min. against heads of from 15 to 60 ft. and at speeds of from 225 to 2500 r.p.m. They weigh from 800 to 27,000 lb. complete.

In the type of turbine used for driving the auxiliaries there is a single-disk rotor with a single row of blades. In the noncondensing type the steam expands once and passes through the blades twice, whereas in the condensing type it expands twice and passes through the blades four times. By redirecting the steam through the same row of blades several times, its energy is fully utilized by a simple construction.

⁂

Caps Oil Separator

The separator shown in section in the accompanying drawings has been recently designed by John E. Caps, of the Cartwright-Caps Co, Chicago It is provided with a cone-shaped member on the inlet side whose vertex lies toward the source of the exhaust steam. On the convex surface of the cone are mounted four curved blades to give a whirling motion to the steam and facilitate the separating process. Impinging against the blades and the surface of the cone, the steam is deflected against the inner surface of the separator wall where it encounters a series of ribs and eventually passes through the outlet at the opposite end of the separator. The condensation and the oil drain into the receiving chamber below the body of the separator and are drained off through the bottom connection. In the sectional and detail views, the construction of the separator is clearly shown.



Section of Caps Oil Separator

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Concrete Mixtures

A good way to determine the amount of sand and cement necessary to add to a given grade of crushed stone for foundations, etc., is as follows:

Fill a box or other receptacle of a known size level full of broken stone. Then put in enough sand to fill the voids. This will determine the amount of sand necessary. Next put as much water into the box as will in turn fill the voids which the sand has left. This will indicate the amount of cement required. An additional 5 to 10 per cent. of cement should be used to allow for its not being thoroughly distributed in the mixing process, but it should not be considered as strengthening the concrete.

It will be found that the proportions vary considerably with the different grades of stone and sand used. Therefore, the proportions so often arbitrarily referred to may or may not be the best to use in a given case.

Depreciation and How It Is Applied

By Charles H. Bromley

SYNOPSIS—This article treats in a simple way the essentials of depreciation as a fixed charge in power-plant practice.

⁂

Rate of Depreciation

To depreciate a thing is to lower its value—make it worth less at the end of a given time than it was when new. In power-plant practice it is a charge made against the deterioration, the "wearingoutness," either slow or fast, of the plant or any particular apparatus in it. Depreciation infers a money value, a state of physical condition. The rate of depreciation or deterioration is the amount the plant wears out *yearly*. This rate is based on the assumed useful life of the plant or apparatus and is expressed in per cent. of this period, which is taken as the base, or 100 per cent. Thus, if we assume that a plant will last 25 years, then 25 years is 100 per cent. of the lifetime of the plant, and the rate at which it must wear out yearly will obviously be 4 per cent. If it lasts 40 years, the rate of deterioration will be

$$100 \div 40 = 2.5, \textit{ or } 2.5 \textit{ per cent.}$$

If it lasts 20 years the rate is 5 per cent.; 15 years, 6.67 per cent.; 10 years, 10 per cent., etc.

The depreciation *charge* is based on and equal to the life deterioration rate, but it represents an amount of money which is the same percentage of the original investment, 100 per cent., as the deterioration rate is a percentage of the useful lifetime of the plant, 100 per cent. The depreciation charge is the amount of money which, if set aside each year for the number of years which the plant lasts, would equal the original cost of the plant, or the original investment.

Suppose we install a plant for $50,000 and assume that the plant will last 20 years. It will wear out at the rate of 5 per cent. per year for 20 years, at the end of which time the original plant will have gone, and so will the original investment of $50,000. If this annual charge is put into a fund with which to buy a new plant to replace the one worn out, it is called a sinking fund.

Interest

So far interest has not been considered in connection with the depreciation charge, but in practice it should be. Experience teaches that apparatus does not wear out uniformly; the rate increases with the age of the apparatus, providing the conditions of its use are unchanged. Work that will wear out a young man slowly will wear out an old man quickly.

When interest is added to the depreciation fund or rate it naturally will be compounded. The amount in the fund set aside at compound interest will increase slowly at first, but year by year it will increase more rapidly. The fund, therefore, increases at a rate which about equals the ever increasing rate of deterioration. In actual business this sum usually is not regularly put aside, invested, and banked at interest, but the bookkeeping department should account for this fund just as though it were invested at current rates of interest.

Obsolescence

In small, and even in many large manufacturing plants, the depreciation charge covers or includes the decrease in plant value, due to its going out of date or becoming too uneconomical as compared to more modern equipment. The physical value of the equipment may be nearly as good as when new, but its commercial value is less; it has depreciated, because other equipment, more economical and suitable, is available in the market. One could hardly be induced to accept as a gift a 1903 model automobile, even though it had never been used and was in perfect physical condition. It is out of date, obsolete. Power-plant equipment becomes obsolete, and when its value decreases in this way it is either provided for in the depreciation charge or a separate charge, called an obsolescence charge, is made. In small plants this charge is included under depreciation, but in large ones, especially the central stations, it is often made a separate charge.

An example of equipment in good physical condition becoming obsolete is that given by the Seventy-Fourth St. station of the Interborough Rapid Transit Co., New York City, where a number of angle-compound reciprocating engines of 5500 hp. each are to be discarded for three turbines of 30,000 kw. each. Even though these units are to be scrapped it is notable that the overall economy of this station is greater now than when comparatively new.

It should be understood that it is most difficult to tell how long a plant will give useful service, and therefore depreciation rates as usually assigned are really only an approximation. The interest to be added to the depreciation charge is governed by the interest rates current in any particular locality.

Experience teaches that different apparatus in any plant does not depreciate uniformly; some kinds having much shorter lives than others. Then, too, certain parts of a machine may wear out several times before the rest has deteriorated. The practical result is that to avoid great complexity of accounts we should, and usually do, include the whole plant in the depreciation charge.

The main fact for the engineer to remember is that deterioration and depreciation are directly influenced and dependent on the care given the plant. A careless, incompetent man may increase the depreciation rate so much more than when under careful management, that he could be fined for his work, or misapplied work, instead of receiving a salary.

Relation of Repairs to Depreciation

If we operated a machine for its entire life without spending a cent on it for repairs or replacements, no complication of items would arise to make the depreciation charge confusing. In practice we imitate this condition. For convenience only, we keep the depreciation charge separately and include repair and renewal charges under maintenance, which in most plants is not considered a fixed charge but a variable expense in addition to the cost of attendance. It is best to make a separate charge for supplies instead of adding it to maintenance as is practiced by some engineers.

Draft Loss through Boilers*

By Osborn Monnett†

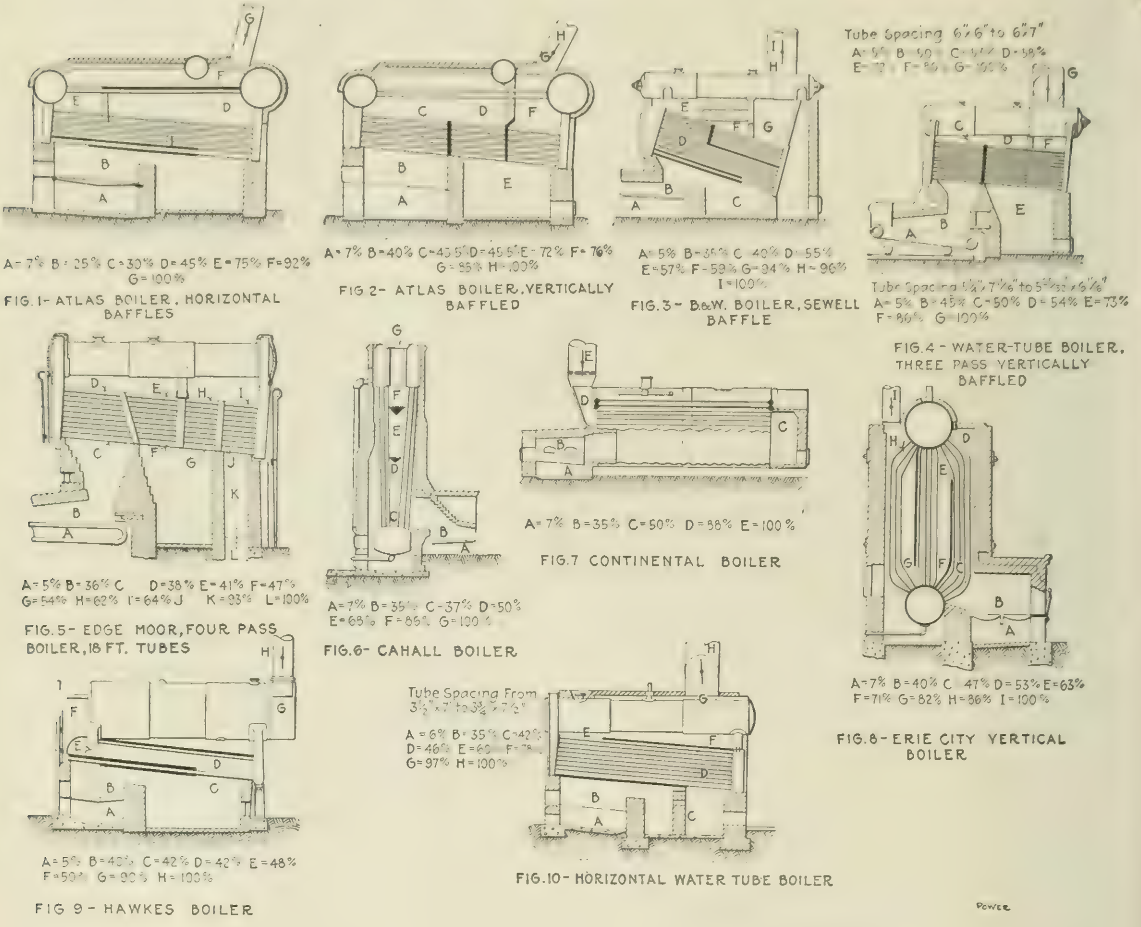
SYNOPSIS—Taking the draft at the stack side of the damper as 100 per cent., relative draft readings at other points through the boiler are given in percentages. The data cover practically all types of stationary boilers on the American market.

⁂

A careful study has been made of installations in commercial operation to determine the draft loss through the average boiler setting as ordinarily installed. The data given are not actual readings, as these may vary widely under different conditions even through the same boiler. Rather, the attempt has been made to indicate the draft relations that can reasonably be expected in the average plant as obtained from a large number of different readings on each type of boiler. A plan has been worked out by which the draft available through the boiler is expressed in percentage of the draft at the stack side of the damper, recognizing the fact that the damper is an integral part of the boiler setting and must be included in studying draft conditions.

These data have proved to be sufficiently accurate to serve as a guide in supervising the plans of at least 1000 boilers a year for the past three years, using Illinois coals on hand-fired grates having an air space of 45 to 55 per cent. and rates of combustion of from 20 to 30 lb. of coal per square foot. The data also apply to mechanical stokers burning from 25 to 40 lb. of coal per square foot of grate, with the capacities in either case ranging from rating to 50 per cent. overload.

Taking the draft at the stack side of the damper as 100 per cent. and the draft available at any given point in the setting as a percentage of it, reduces the problem to a standard basis and simplifies the calculations necessary. In the accompanying illustrations enough types are given to enable the designer to approximate the draft loss through nearly any make of boiler on the American market. With the data on the sketches it is possible to calculate the stack height necessary for a given draft



A=7% B=25% C=30% D=45% E=75% F=92% G=100%

FIG. 1—ATLAS BOILER, HORIZONTAL BAFFLES

A=7% B=40% C=43.5% D=45.5% E=72% F=76% G=85% H=100%

FIG 2—ATLAS BOILER, VERTICALLY BAFFLED

A=5% B=35% C=40% D=55% E=57% F=59% G=94% H=96% I=100%

FIG. 3—B.&W. BOILER, SEWELL BAFFLE

Tube Spacing 6"×6" to 6"×7"
A=5% B=50% C=54% D=58% E=73% F=86% G=100%

Tube Spacing 5¼"×7⅛" to 5 [illegible]/32"×6⅞"
A=5% B=45% C=50% D=54% E=73% F=86% G=100%

FIG. 4—WATER-TUBE BOILER, THREE PASS VERTICALLY BAFFLED

A=5% B=36% C D=38% E=41% F=47% G=54% H=62% I=64% J K=93% L=100%

FIG. 5—EDGE MOOR, FOUR PASS BOILER, 18 FT. TUBES

A=7% B=35% C=37% D=50% E=68% F=86% G=100%

FIG. 6—CAHALL BOILER

A=7% B=35% C=50% D=88% E=100%

FIG. 7 CONTINENTAL BOILER

A=7% B=40% C 47% D=53% E=63% F=71% G=82% H=86% I=100%

FIG. 8—ERIE CITY VERTICAL BOILER

A=5% B=40% C=42% D=42% E=48% F=50% G=90% H=100%

FIG 9—HAWKES BOILER

Tube Spacing From 3½"×7" to 3¾"×7½"
A=6% B=35% C=42% D=46% E=69% F=78% G=97% H=100%

FIG. 10—HORIZONTAL WATER TUBE BOILER

Showing Draft Losses through Ordinary Boiler Settings

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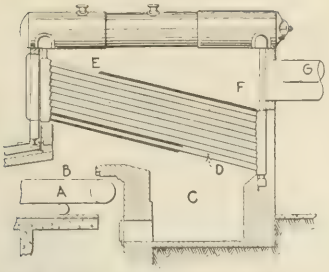
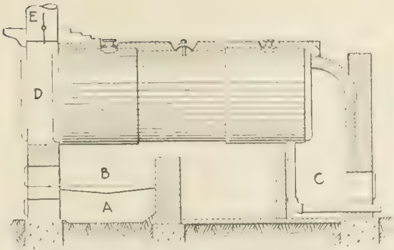
*Copyrighted, 1914, by Osborn Monnett.

†Smoke inspector, City of Chicago.



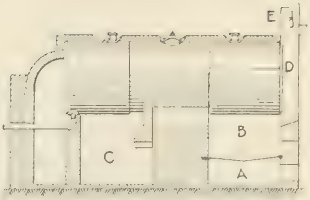
A = 5% B = 40% C = 52% D = 57% E = 80% F = 86% G = 100%

FIG. 11 - HORIZONTAL WATER TUBE HORIZONTALLY BAFFLED, SINGLE PASS, TUBE SPACING 5 × 6½ TO 6 × 7 INCH



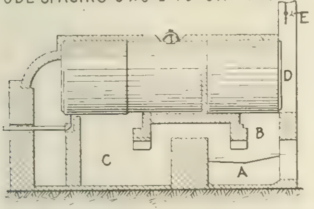
A = 7% B = 44% C = 48% D = 70% E = 100%

FIG. 12 - RETURN TUBULAR BOILER, PLAIN SETTING OLD TYPE DAMPER AND GAS PASSES



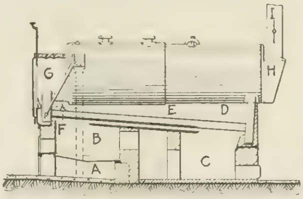
A = 7% B = 53% C = 60% D = 79% E = 100%

FIG. 13 - RETURN TUBULAR BOILER DOUBLE-ARCH BRIDGEWALL FURNACE



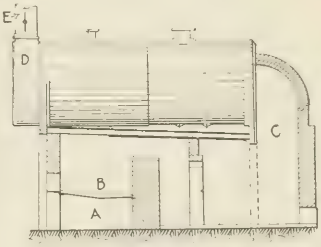
A = 7% B = 40% C = 52% D = 87% E = 100%

FIG. 14 - RETURN TUBULAR BOILER, LOW PRESSURE



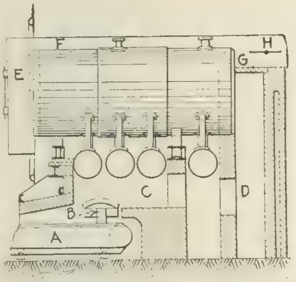
A = 7% B = 40% C = 47% D = 47% E = 48% F = 48% G = 50% H = 87% I = 100%

FIG. 15 - KROESCHELL COMBINATION BOILER



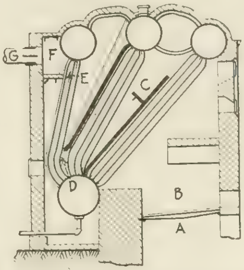
A = 8% B = 40% C = 48% D = 75% E = 100%

FIG. 16 - LYONS BOILER



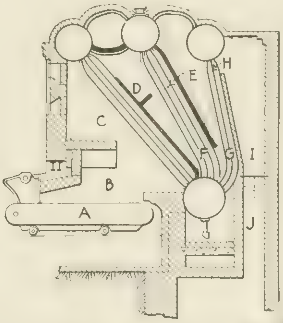
A = 5% B = 15% C = 17% D = 35% E = 83% F = 92% G = 97% H = 100%

FIG. 17 - SEDERHOLM BOILER (3 INCH TUBES)



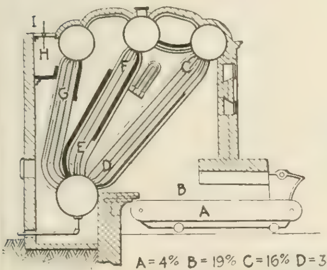
A = 8% B = 35% C = 41% D = 49% E = 68% F = 93% G = 100%

FIG. 18 - STIRLING BOILER STANDARD SETTING



A = 5% B = 14% C = 16% D = 29% E = 31% F = 57% G = 59% H = 65% I = 83% J = 100%

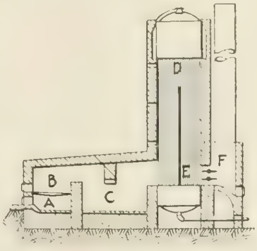
FIG. 19 - STIRLING BOILER. UNDERGROUND BREECHING



A = 4% B = 19% C = 16% D = 33% E = 33% F = 42% G = 68% H = 93% I = 100%

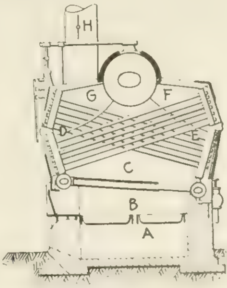
FIG. 20 - STIRLING BOILER (FIVE PASS)

POWER



A = 5% B = 42% C = 48% D = 25% E = 75% F = 100%

FIG. 21 - WICKES VERTICAL BOILER



A = 7% B = 45% C = 45% D = 62% E = 57% F = 46% G = 66% H = 100%

FIG. 22 - WORTHINGTON BOILER

MORE BOILER SETTINGS, SHOWING DRAFT LOSSES over the fire, after the breeching losses are added to the draft intensity required at the damper. For instance, in Fig. 11 the percentage of draft over the fire is given as 40 per cent. of the draft at the stack side of the damper. If, on a given job, it is desired to obtain a draft of 0.32 in. over the fire with this boiler, then there will be required at the stack side of the damper a draft that is the equivalent of

$$\frac{0.32 \times 100}{40} = 0.8 \textit{ in. of water}$$

to which must be added the breeching loss before calculating the stack height.

This information is of value also when studying the draft conditions in existing plants. Any unusual drop between two points in a setting will indicate at once that something is wrong.

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Releasing Pawled Elevator Cars

By William Kavanagh

SYNOPSIS—Why elevators cars pawl in the shaft. What to do to release a pawled car and to liberate the imprisoned passengers. Some mechanical troubles that cause a car to pawl when it ought not to, and how to discover and remedy them.

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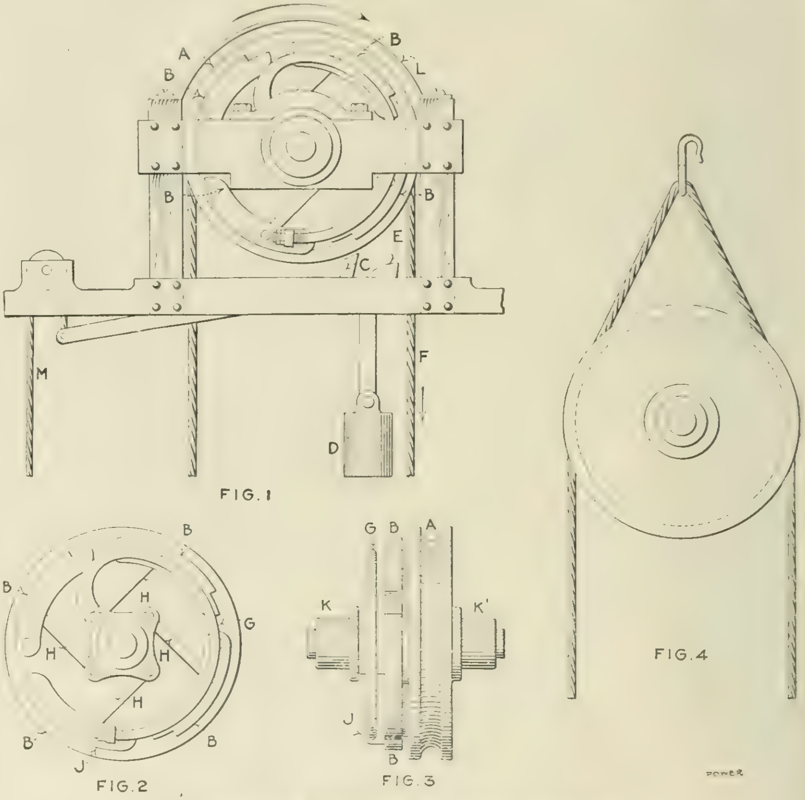
Usually if an electric elevator pawls in the shaft it demonstrates that the safeties operated at the proper time and prevented the car from falling to the lowest floor of the elevator shaft. When the safeties operate and lock the car in the shaft at times when such is not required, it indicates that the mechanism controlling the action of the safeties is disordered. Such trouble should be found and immediately remedied. While it is important to know that the safeties are in good order, still a continuous repetition of cars pawling, whether loaded or unloaded, will create dissatisfaction among tenants and give the engineer much worry.

When a car pawls from overloading, the car operator is to blame for allowing too many persons aboard. In the morning, the rush of the passengers is upward, and at this time there are fewer cars pawled than in the evening, when there is a heavy rush of passengers downward. Crowding the cars in the evening often causes pawling, the car operator, being anxious to carry all of the passengers possible, will risk an overload, which causes the safeties to act and lock the car, sometimes between floors.

When a loaded car is pawled between floors, the engineer and his assistants must use good judgment to prevent any undue excitement of the imprisoned passengers, and act quickly to release the car. To do this, one man is sent to the operating board while another is placed where he can see the safeties. Two or more men are posted on top of the pawled car, while one or two are sent to the bottom of the shaft in which the car is locked. The men being placed, the engineer gives the word to unlock the governor. After the governor is reset, the engineer orders the man at the control board to take up the slack, which is done by slightly lifting the car from below or by pulling on the lifting cables. This operation being over, the men at the bottom of the shaft, and also the men on top of the car, are ordered to pull on the safety cable.

All the men will now pull together on the safety cable in the direction that will unlock the safeties. The man watching the safeties from beneath the car can then determine the direction in which the safety cable must be pulled, and the instant the safeties are unlocked the circuit for the car control will become closed, enabling the operator to start the car. The safety clutches being



Views of Parts of Elevator Governor

loosened from the rails, the operator is now ordered to throw the controller on the "up" motion, and the car is brought level with the floor directly above, when the passengers are permitted to leave.

It is not advisable to throw the controller on the "down" motion, especially when the car is filled with passengers. After all the passengers are out, the car is run to the upper limit of travel, and an investigation made into the cause of pawling.

A car will pawl from any or all of the following conditions: (1) If the governor is not properly set; (2) if the safety rope is stranded; (3) if the governor is worn or the governor spring is weak; (4) if the car is suddenly "jumped" into speed; (5) if the car is overloaded; (6) if the safety mechanism permits of creeping.

A governor of the instantaneous type is shown in Fig. 1, and when the car is traveling downward the rotation of the sheave wheel will be in the direction of the arrow. Assume that for some reason the car descends at an abnormal rate of speed. The sheave *A* will be rotated at a high rate of speed, throwing the weights *B* beyond their normal plane, which will cause them to strike the trigger *C*, liberating the weight *D*, the action of which will cause the wedge *E* to bind the cable *F*, locking the safety cable in the governor frame and preventing its further travel. The moment cable *F* becomes locked, the stress thus imposed on it is communicated to the safety mechanism beneath the car. This action causes the safety springs to act on the safety clutches, which grip the car guide rails with a vise-like grip, compelling the car to stop in its descent within a very small distance. When the safety springs act, the circuit controlling the operating board is broken, preventing further rotation of the motor actuating the hoisting and lowering mechanism. If this circuit were not broken, the motor would keep on running and eventually unwind the drum cables, causing considerable labor to straighten out the cables for the proper direction of travel.

Fig. 2 illustrates the governor wheel removed from its frame as shown in Fig. 1. The weights are shown at *B* and the spring at *G*. It will be noticed that there are four tangential levers *H*. Those levers are connected to the square yoke and to the weights as indicated. The spring *G* also is connected to the yoke and the weight *J*. The spring is made fast at this point by means of two small nuts and the tension on *G* can be varied to suit the load or velocity of rotation. If the tension is slight, a low velocity is all that will be required to throw the weights beyond their normal plane, thus permitting them to strike the trigger shown in Fig. 1.

Again, when the levers or pins to which the levers are attached become worn, lost motion will prevail, and the weights will trip the governor even though the tension on the spring is greater than normal. If the nuts at *J* are not set up tight, the tension on *G* will become insufficient, allowing the weights to trip the governor and pawl the car. Fig. 3 is a side view of Fig. 2; it shows the solid brass bushings *KK*, in which the shaft carrying the sheave *A* rotates. If the bearing *KK* becomes worn, the governor wheel or the sheave *A* will cant toward the trigger, tripping the safety mechanism. Whenever a governor wheel is worn sufficiently to permit tripping it must be removed.

Fig. 4 shows the method of removing the worn wheel. The tension sheave in the elevator pit or bottom of the well is raised to its limit of height, and a hook is placed under the governor rope. The rope may now be raised above the wheel as indicated, the wheel removed and a new one put on.

The quickness with which a stalled car may be put in motion depends on how the engine-room force has been trained. With a well trained crew, a pawled car containing, say, a dozen passengers, should be in running order in fifteen minutes. This time may be much shortened if a flat band of strap iron is bolted circumferentially above the governor wheel as shown at *L*, Fig. 1.

When the governor cable becomes locked in the frame, the shock it receives often causes the rope or cable to jump out of the sheave, causing considerable delay to replace it. This iron band obviates this trouble, and again when the governor, unlocking the rope, shown at *M*, Fig. 1, extends the entire length of the shaft, it facilitates matters in getting the car in running condition. Thus we see that where those two additions are made to the governor mechanism, the governor cable is prevented from jumping out of the sheave and can be unlocked from any part of the shaft, saving the time required to reach the roof or pent house where the governor wheel is located.

*

Hints on Starting a Compression Plant

By William L. Keil

In many plants the engineer has to occasionally run an ice or refrigeration machine; in others only during the hot season. To those engineers lacking the experience of the refrigeration man, practical hints are usually welcome.

There are many types of refrigeration machines; large ones, small ones, double- and single-acting; some with an oil system, others without (dry system); but they all work on the same principle. Every engineer knows what to do when starting an ordinary water or air pump; he first sees that the suction and discharge valves are open before he turns on the steam. About the same things are done when starting a refrigeration machine, for the ammonia compressor is really a high-class pump.

When starting a compressor, the first thing is to see that the discharge valve is open. As all double-acting machines have equalizers, see that they are open, and then start slowly. Next, slowly open the valves on the suction line, then turn the oil on to lubricate the valves and then the water to keep the compressor cool, or the oil, if the machine has an oil system. Now close the equalizing cocks Watch the back-pressure gage, if it indicates the pressure one finds best to carry, the main liquid valve should be opened slowly. The water over the ammonia condenser should not be turned on until the high-pressure gage indicates the pressure usually carried.

While the machine runs the frost may come back to the compressors from two causes: From some liquid that laid in the suction line, or from one or more regulating valves being open too wide. In the first case let the machine run a little faster; if the frost does not disappear soon, look at the return pipes of the different rooms. Be sure to shut off on the room from which the pipe is most heavily frosted, for the frost on the return from the room where the frost comes back strongly may travel along the return lines of the other rooms. If such is the case, it is difficult for the inexperienced engineer to tell which one of the rooms freezes back most. To locate the room or rooms, wet the finger tips and touch the returns; if the fingers stick then the room from which the frost comes has been located. What has been thus far explained applies to the direct system only.

THE INDIRECT SYSTEM

By indirect system is meant a system where brine is cooled to freeze water or produce frost around the coils in the different rooms through which it is circulated by means of the brine pump. For the smaller refrigeration plant, hotels, etc., this system is used more extensively than the direct system.

The brine tank should always contain brine enough to entirely submerge the coils. It must not be less than 70 nor more than 90 deg. Baumé and should be constantly agitated; it must never be cooled lower than 8 or 10 deg. F. When down that low, the machine may be stopped while the agitating pump is kept running.

⁂

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Several kinds of mine locomotives were seen in operation, one of the gasoline type. A combination electric locomotive and haulage system was found at one colliery, the haulage engine drawing the loaded cars out of the mine, and the electric, coming out light, hauling the empty cars back into the mine.

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It is the general supposition among those not familiar with present-day coal-mine practice that mules are used almost exclusively in coal mines for hauling coal from the working face to the bottom of the shaft. I was surprised during my travels about the mines to note how extensively air and electric haulage was used, and to find that in the larger mines mules were worked only for gathering, some type of locomotive being used for the long hauls.

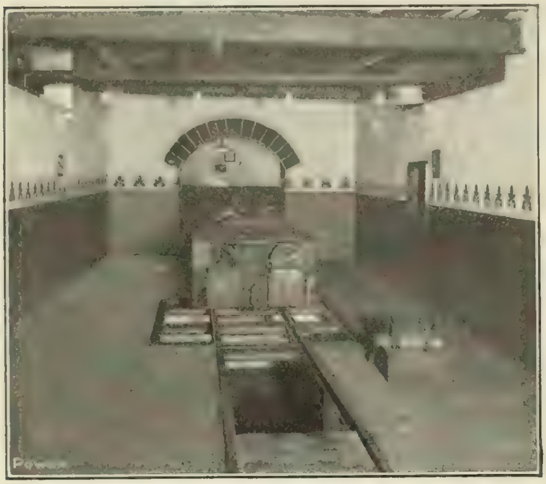

Fig. 1. Electric Locomotive Room in Mine

In our travels Hunter and I had run upon various kinds of mine haulage, with the exception of steam locomotives, which had been tried, Hunter said, but owing to the volume of smoke and gases given off had been discarded.

In our conversations, Hunter had also stated that air locomotives were used in deep, gaseous mines, because they operate without spark or fire of any kind and at the same time added to the ventilation, supplying clean air to that in the mine. The disadvantage of the air locomotive is that it is bulky and requires high and wide entries in which to run. More than that, it cannot go far from a charging station, which renders its use less flexible than the electric or the gasoline locomotive. Then there is the upkeep of not only the locomotives but of the pipe lines, when high pressures are maintained.

"Simplicity is the prevailing feature of the electric locomotive," said Hunter, as we stood looking at one in the motor room, Fig. 1, down in No. 9 colliery of the Pennsylvania Coal Co. This repair room was 10x65 ft. in width and length and 12 ft. high. The roof was of natural slate, which was reinforced by I-beams, as shown. The walls were cemented and painted and the floor was of concrete. A tool room built in the stone formation is shown at the rear of the electric locomotive.

"You see," said Hunter, "an electric locomotive has really but one rotating part and mechanically it is the simplest motor used about a mine; so long as electricity is supplied it will do its work, providing nothing burns out. As there is danger of gases being ignited from sparks formed between the trolley wheel and the wire, the electric locomotive is not the machine to use in a gaseous mine.

"You have read of trolley lines costing so many dollars per mile to construct, but you can bet every bean you've got that mine tracks and equipment cost money, too. The expense of installing the trolley wire and feeders alone is no small item, and the rails have to be bonded to carry the return current, which adds to the expense. This and the cost of the locomotive are but a small part of the entire expenditure for electrical equipment, including power-plant apparatus. Aside from the danger from gas ignition, there is the danger of the workmen being shocked."

"From your point of view, the electric and air locomotive is not in it with mule haulage for safety or cheapness?"

Hunter gave a grin before answering and then said. "Nobody about a mine will bank on a mule being safe, especially from a stern exposure. He can haul an exceedingly heavy load, but his mileage is small and he is liable to injury. Now about the locomotive. I don't disapprove of them; I just happened to tell you of some of their disadvantages. I don't know how some of the large mines could get along without them and still maintain their output of coal. You remember at No. 35 Colliery of the Berwind-White Co., at Windber, we saw a 20-ton six-drive electric locomotive drawing something like 110 empty coal cars (Fig. 2).

"They were to be taken into the mine and a loaded train brought out while dozens of mules would have made about a quarter of the trip in with empties. At this company's mines a railway car is loaded with coal every few minutes. To get the output of the mines to market, about 4,285,521 tons per year, would take a bunch of mules."

"Just a few," was the only reply I could make.

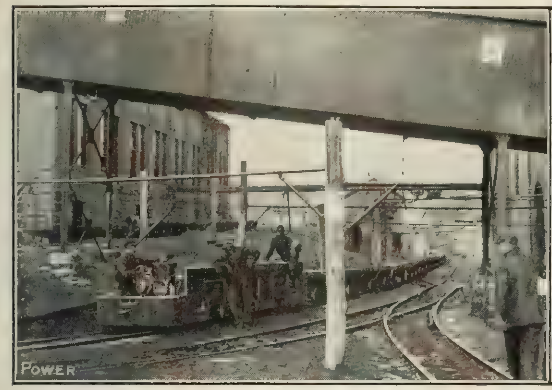

Fig. 2. Twenty-Ton Locomotive Drawing 110 Empty Mine Cars

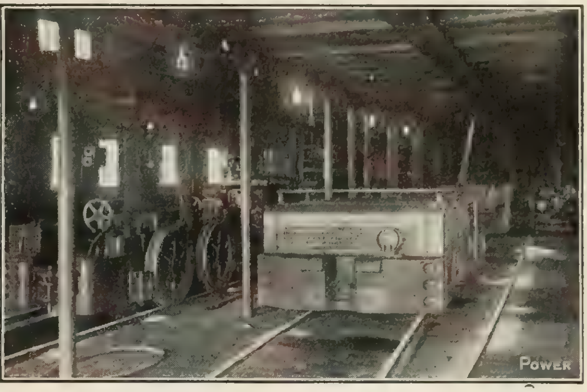

Fig. 3. Locomotive Barn and Repair Shop

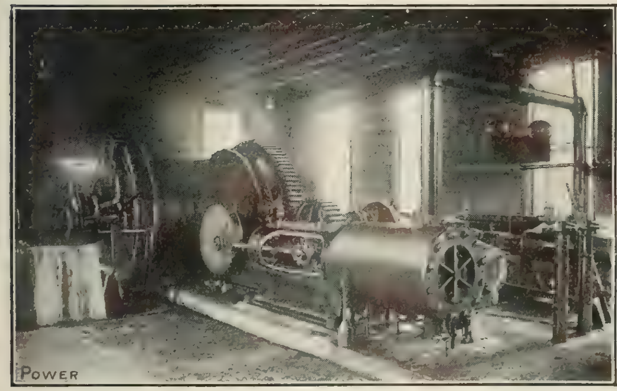

Fig. 4. Haulage Engine. A Locomotive Draws the Empty Cars into the Mine

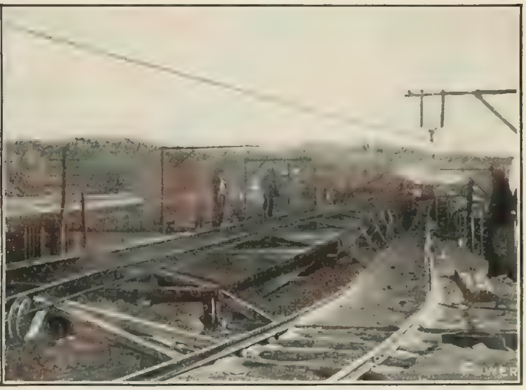

Fig. 5. As the Cars Enter the Mine, the Haulage Rope Is Snapped from One Track Level to the Other

Several days later we came to the Moshannon colliery No. 33 of the Pennsylvania Coal & Coke Co., at Patton, Penn. This mine is electrically operated and an examination of the motor house, Fig. 3, was interesting. There was a 10-ton locomotive with equipment of 15-ton rating. The motor and driving wheels were connected by an intermediate gear. The gear wheels were made of a spider shrunk to the wheel shafts, and the toothed rims were made in sections, so that when the teeth became worn or broken a new gear rim could be bolted to the spider by six $1\frac{1}{8}$-in. bolts, without disturbing any other part of the machine. All ordinary repairs of the electrical equipment are made at the mine, a machine shop being at one end of the locomotive house.

In most mines employing electric locomotive or haulage engines, each is operated separately, but at No. 28, Pardee, colliery we found a second-motion haulage engine, Fig. 4, working in connection with an electric locomotive. The pinion on the engine crankshaft meshes with a gear wheel keyed to the drum shaft. The rim of the gear is made in six sections, and if a tooth breaks, that section can be replaced at small expense. The drum is driven by a friction on the shaft. The brakes are operated by steam. The engine draws the loaded cars from the mine, but no tail rope is required as the electric locomotive draws the empty cars into the mine, and follows the train load of 70 tons from the mine up a 5 per cent. grade in places.

It is figured that this is cheaper than to have the locomotive do all the work. The locomotive was used to draw the empties from the tipple up the incline, Fig. 5, and then to control the empty train going into the mine and to also draw the haulage cable into the mine ready for the engine to haul out another loaded train. While the cable was being drawn into the mine the winding drum ran loose, the engine being stopped.

By referring to Fig. 5 it will be seen that the loaded cars are on the upper track and that the empties are switched back, after dumping, to the lower track. The haulage cable is hooked onto the rear end of the last car of the train. In order to get the cable back to the upper track after the empties have reached the same level, the engineer of the haulage engine puts the brake on the drum, which has been running loose on its shaft. This snaps the cable up over the timbers, shown at the right of the platform, onto the rollers beside the track, ready for the next loaded train. The cable is shown just before reaching the rollers upon which it runs.

While at this colliery, the sky became overcast and rain threatened to spoil the rest of the day. Nevertheless, we made our way to No. 35 colliery of the same company. As we picked our steps over the uneven ties of the railroad track, Hunter said, "Did you ever see a gasoline mine locomotive?" Upon my negative reply he continued: "They haven't been over 10 years in this country, but they were used in Europe about the time the automobile came into service. They are operated in mines the same as air or electric locomotives, and eliminate the necessity for an outside power plant."

When we arrived at the mine we found a Whitcomb gasoline locomotive just coming out of the level with 22 loaded cars of coal, or approximately 19 tons, total. The grade in places was over 5 per cent., but in some parts of the mine the speed was approximately eight miles per hour. The machine is shown in Figs. 6 and 7.

"That motor is made in a number of sizes," remarked Hunter, watching the last of the empty coal cars disappear in the hole in the hill, "ranging from 2½ to 16 tons. All are fitted with four-cylinder, four-cycle horizontally opposed engines ranging from 20 to 125 hp. The drive is from the engine into the transmission, which provides for two speeds in either direction."

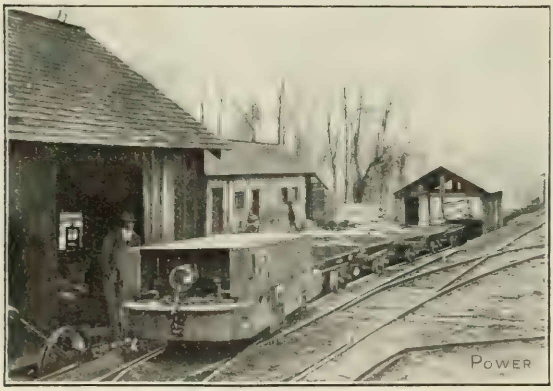

FIG. 6. GASOLINE LOCOMOTIVE AND TRAIN OF EMPTY CARS

"How is that accomplished?" I asked, as we examined the locomotive after its return from the mine.

"Well, one of the driving shafts has a bevel pinion which engages with two bevel gears in the transmission. On the back of these two gears are clutches, and as the gears run in opposite directions, on account of meshing with the one pinion, a forward or reverse motion is given.

"On the forward or reverse shaft there are two spur pinions that engage with two spur gears on a lower shaft. On these gears are also fitted clutches which provide for high and low speed, giving a gear capable of making four miles an hour on slow speed and eight miles on high speed, with the engine running at about 500 r.p.m. The engine has a range of speed of from 300 to 750 r.p.m. The front high- and low-speed shafts are driven by a double chain drive and from the front to the rear axle by a chain drive, so that all four wheels are drive wheels. This machine, as, in fact, all others, will develop a tractive effort of about 20 per cent. of its weight."

As we left the mine a drizzle began, and before we reached the nearest hotel we were fit subjects for a steam drying establishment. After supper that night, while in conversation with some mining men, we learned of a mining proposition that sounded mighty interesting, and we decided to look it over the next day. The rain was still beating against the windows as we went to our rooms, and after tumbling into a cold, damp-feeling bed, I finally went to sleep, inhaling the mixed odor of new paint and insecticide.

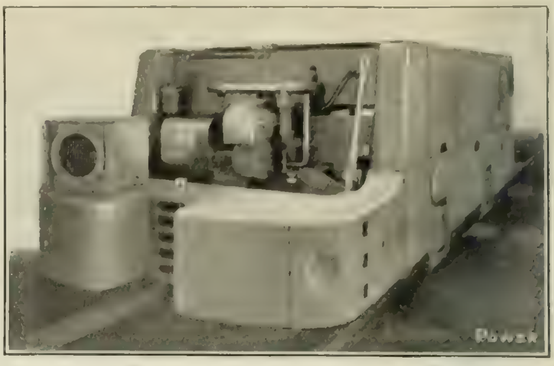

FIG. 7. OPERATOR'S END OF GASOLINE LOCOMOTIVE

Air-Gap Equalization

In the case of a series-connected multipolar armature, for every conductor in a given position under a pole of given polarity, there is in series with it another conductor in the same relative position under a pole of opposite polarity. Therefore, if on account of excessive bearing wear, or any other reason, the air gap is greater on one magnetic field, there is in series with it a conductor in a strong magnetic field. As such an armature has only two paths through it, unevenness of the air gap around it does not affect the distribution of current in the armature conductors.

In a multiple-connected armature, however, there are as many independent current paths in the armature winding as there are poles in the machine and equalization of the total current through the several independent paths is affected by unequal distribution of the air gap. Equalizing connections between equipotential armature conductors help to equalize the current among the different paths, but there is a limit to the capacity and the effectiveness of these equalizers. For this reason, modern units are generally constructed to permit of equalizing the gap.

An operator complained that the equalizer rings were heating more than they should and that the brushes were sparking. Inspection showed that wear in the armature bearings had let the armature down, thereby making a small gap at the bottom and a large one at the top. As the machine had no air-gap equalizing devices, new bearings had to be fitted.

Gas-Engine Indicator Diagrams

By George W. Muench

SYNOPSIS—How some of the common gas-engine troubles, such as improper timing of valves and ignition, preignition, faulty compression, excessive back pressure, etc., may be detected by the indicator diagram.

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As a trouble finder, the indicator is not used so universally in gas-engine operation as with steam engines. Its use is necessary for determining the indicated horsepower of a gas engine, for in this way only can the true mean effective pressure be found. However, it can be made to serve a large number of other useful purposes, as a diagram properly taken will show the timing of the ignition, the valve setting, the quality of the mixture, the exhaust back pressure, the preignition, the condition of compression, and the other conditions affecting the proper operation of the engine. As a rule, it is not as simple to operate an indicator on a gas engine as on a steam engine; also, higher pressures and sudden changes in pressure must be handled.

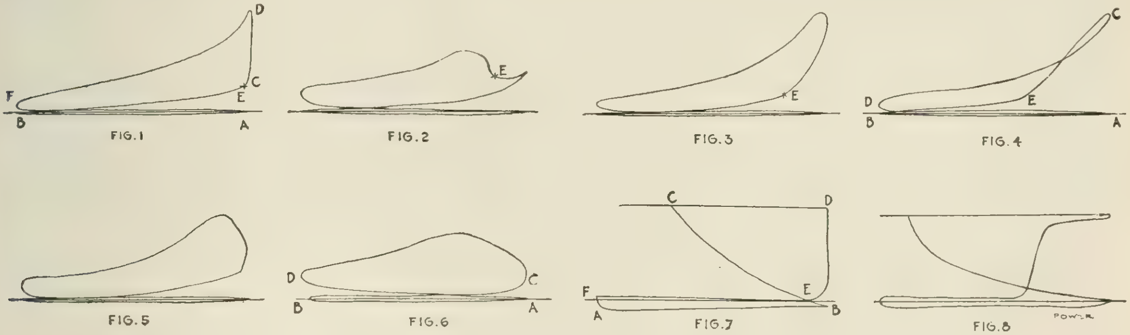

FIG. 1 FIG. 2 FIG. 3 FIG. 4

FIG. 5 FIG. 6 FIG. 7 FIG. 8

Sample Gas-Engine Indicator Diagrams

Fig. 1 represents a normal diagram from a four-stroke-cycle engine. The line *AB* represents the suction stroke, slightly below the atmospheric line, and *BC* represents the compression stroke with the explosion occurring at *E,* the pressure jumping quickly to a maximum at *D.* The power or expansion stroke is represented by the line *DF.* At *F* the exhaust valve opens slightly before the completion of the stroke and *FA* represents the period of exhaust. The area included between the suction and the exhaust lines represents lost work, therefore, all attempts should be toward keeping this as small as possible. Comparing other diagrams with the ideal, the defects are easily located.

Fig. 2 shows a diagram with ignition too late, the explosion occurring at *E,* beyond dead center some distance outward on the expansion stroke.

In Fig. 3 the ignition is too early, the explosion occurring at *E.* Figs. 2 and 3 are actual diagrams taken on an engine.

Premature ignition is shown in Fig. 4; *AB* representing the suction stroke. The compression stroke was interrupted by the ignition at *E.* This too early ignition caused the expansive power of the burning gases to be entirely spent before the end of the compression stroke, so that on the starting of the expansion stroke the pressure immediately dropped, and expansion occurred from *C* to *D,* part of the time the pressure being less than during the previous compression stroke, causing the negative loop shown. Under these conditions but little useful work is performed.

Figs. 5 and 6 are actual diagrams, the former showing a slow-burning mixture. The time of ignition was not bad, but maximum pressure was not reached before the piston had traveled a considerable distance on the power stroke. The indicator diagram shows distinctly why it is essential in gas-engine work that the time of ignition must change with the quality of the mixture to get the best results out of the engine.

A variety of troubles are indicated in Fig. 6. In the first place, the compression is very poor, as is shown by the slight rise of the line *BC.* Also, as in the previous case, the mixture is slow burning and the back pressure is high, there not being enough valve lift, or some other obstructions are preventing the rapid escape of the burned gases, as shown by the line *DA,* the line remaining far above the atmospheric line practically its entire length.

Although showing a high back pressure, this diagram does not show clearly the exact time of opening and closing the exhaust valve. For accurately determining the exact valve setting of a gas engine by means of the indicator, it is necessary to have a special low-pressure spring attachment, which consists of a stop limiting the travel of the indicator piston and preventing damage to the instrument. This makes it possible to use very low-pressure springs and, therefore, arrive at the true valve setting, which is essential for economical operation. The valve-gear becomes worn, the valves fouled and stick, the passages obstructed, and other troubles vary the valve setting, which means a loss in power.

Fig. 7 shows a diagram taken with an 8-lb. spring, *AB* is the suction line and *BC* shows part of the compression, the stop preventing further travel of the pencil at *C.* The diagram does not trace the cycle, but at *D* the pressure is low enough to allow the pencil movement. The sudden drop *DE* represents the release of the gases, the rest of the exhaust stroke being *EF.*

Fig. 8 is a stop diagram showing the exhaust opening too late.

Test of Wheeler Turbo Air Pump

A high-vacuum surface-condenser air pump has small relative capacity in terms of free air. The air leakage of a large turbine and surface condenser should not exceed 10 cu.ft. of free air per minute. When this air is withdrawn from the condenser it is at an exceedingly low pressure, even lower than the absolute pressure within the condenser, which is the sum of the vapor and the air pressures. To obtain a high vacuum it is necessary, therefore, that the air be withdrawn at a pressure of a fraction of an inch of mercury, and a volume of 1000 to 10,000 cu.ft. per pound.

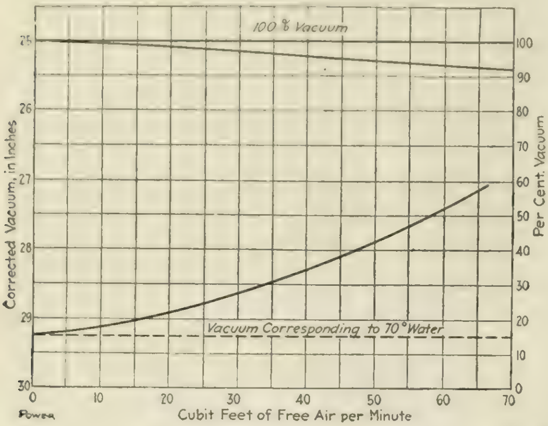

FIG. 1. CURVE OF TEST SHOWING AIR CAPACITY AND VACUUM OF A TURBO AIR PUMP WITH 70 DEG. WATER

With a pump capable of this duty, there remains but two hindrances to the attainment of very high vacuums at the turbine exhaust. The first of these is the quantity of circulating water and its temperature. Assume the water is at 60 deg., then if a 29-in. vacuum is desired, corresponding to a steam temperature of 79 deg., it is evident that the water cannot take up heat when its temperature has gone above 79 deg., in theory, and in practice, above 70 or 75 deg., since some "heat head" is necessary to cause the transmission of heat. If it were required to heat the cooling water up to the temperature of the steam, an infinite amount of tube surface would be needed.

The second hindrance to the attainment of extremely high vacuums is the loss in pressure between the turbine exhaust and the air-pump suction, due to the resistance of the tubes; in other words, the hydro-dynamic loss. This may be reduced to a few tenths of an inch of mercury by the proper arrangement and spacing of the tubes.

It is evident from the foregoing that if sufficient cooling water is used in proportion to the steam to give a rise in temperature of the water of only 10 or 15 deg., it is possible to obtain a vacuum of 29 in. with 60 deg. inlet cooling water, provided the air pump will maintain a vacuum 0.1 to 0.2 inches higher; that is, 29.1 to 29.2.

This is done with modern types of rotary air pumps, with 70-deg. water, instead of 60 deg., as shown by the test of a turbo air pump, reproduced in the chart, Fig. 1. The pump is shown in Figs. 2 and 3. During the test the temperature of the water was 70 degrees. The pump maintained a vacuum 100 per cent. of the theoretical, with closed air suction, and with 10 cu.ft. of free air per minute load a vacuum of 29.1 in., corresponding to 99.7 per cent. of the theoretical. With 18 cu.ft. of free air load, the pump maintained a vacuum of 29 in. The vacuums with increasing load up to 65 cu.ft. of free air per minute are given by the curve.

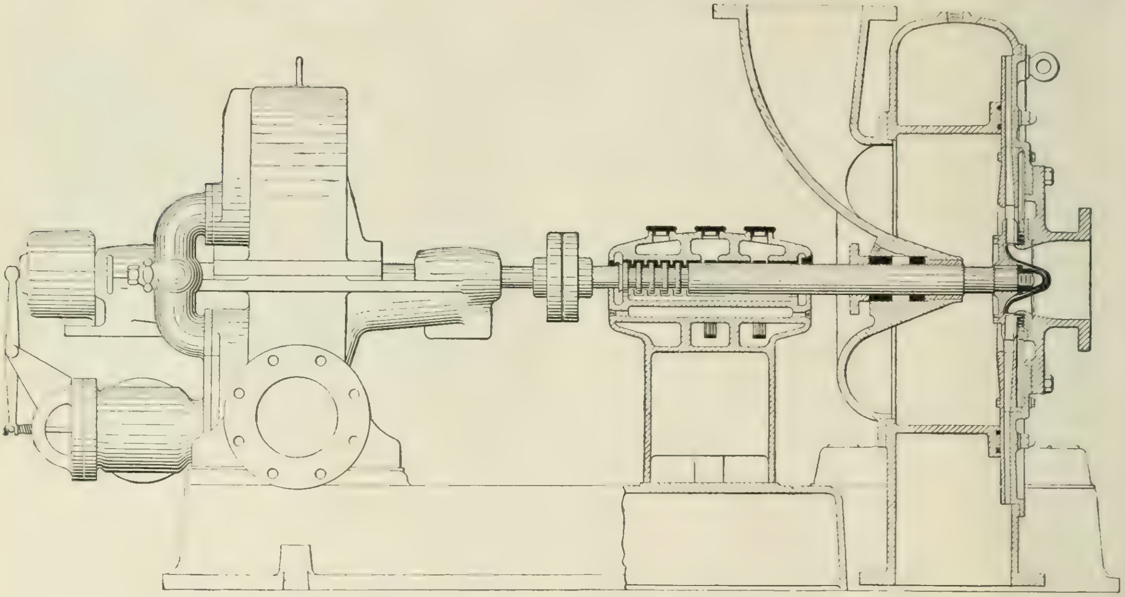

FIG. 2. CROSS-SECTION OF A TURBO AIR PUMP

The design of the turbo air pump, which is built by the Wheeler Condenser & Engineering Co., Carteret, N. J., and is similar to that of the German pump built by the Allgemeine Elektricitäts Gesellschaft, Berlin, is shown by the engravings. The pump has a high-speed small impeller, a ring of diffusion channels and a casing. The impeller discharges water in separate streams into the fixed compression or diffusion ring, whose blades cut the jets into a large number of plugs or layers, which close the entire section of the channels and force the entrapped air out against atmospheric pressure. Air is admitted to the center of the casing by a large nozzle on the bearing side of the pump and is drawn into the diffusor all around the impeller. This gives a large capacity for a small-diameter impeller, rotating at very high speed, and is suitable for directly connected turbine drive.

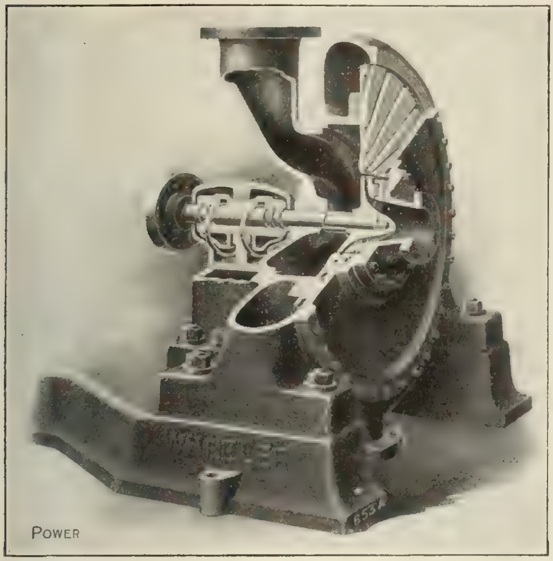

FIG. 3. WHEELER TURBO AIR PUMP

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Improved Hot-Blast Heater

In the heater illustrated, Figs. 1 and 2, an attempt has been made to eliminate the strains on the joints by taking care of the expansion and contraction and to avoid air binding and water-hammer. The straight tubes, all of the same length, are expanded into the front and rear headers, consisting of one-piece boxes. In line with the tube ends are screw plug holes for access in rolling in the pipes and for inspection, cleaning, etc. The tubes are expanded in reamed holes and the ends of the tubes are turned smooth. In the rear header the tubes are expanded against the cast iron. In the front header copper ferrules are used. This header is divided into two parts, the lower being supported by a roller which rests upon an iron plate upon the foundation, and the upper half by a roller resting upon the lower half, thus permitting independent movement.

The steam, or fluid, introduced through a suitable connection into the upper part of the front header, flows through slightly inclined tubes to the rear header, descends to the lower part of the latter and returns through the lower half of the bank of tubes to the lower part of the front header, passing thence to the drip or outlet connection. The circulation is thus positive without short-circuiting or pocketing and the steam assists the air and water of condensation in the natural direction of flow by gravity.

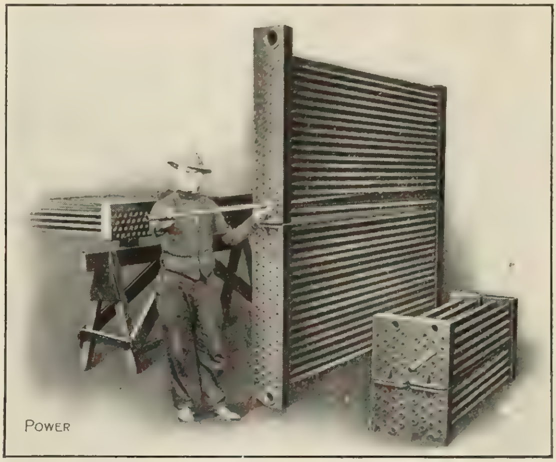


FIG. 1. BOX-HEADER TYPE HOT-BLAST HEATER COIL

The sides of the headers are set tightly together, rendering unnecessary special housing or covering on the two sides and leaving only the top or the bottom to be inclosed, depending upon whether the heater is to rest on the floor or to be suspended close to the ceiling. If it should be desired to apply insulating material, this may be done easily as the access plugs are of the socket type and are flush with the surface of the header.

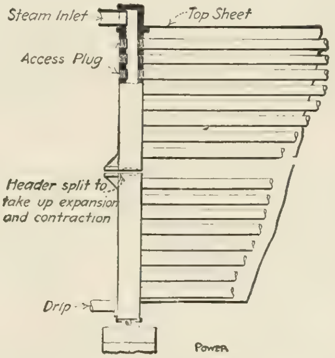


FIG. 2. SHOWING PLUGS OPPOSITE THE TUBES' ENDS

This type of heater coil is manufactured by the Green Fuel Economizer Co., Matteawan, N. Y.

⁂

Significant Operating Saving—The S. R. Smith Infirmary, on Staten Island, N. Y., saved $2000 in operating expenses last year over the previous one by the installation of its own generating plant. It formerly had a heating plant only and bought current from the Richmond Light & Ry. Co. In spite of the saving the load was greater during the past year than before. This saving, though not so large, is significant in view of the size of the plant, which is rated at only 70 kw.

Connecting Series and Shunt Motors

By F. A. Annett

SYNOPSIS—The proper connections between the starter and motor and how to detect wrong connections.

It is the general practice among electrical manufacturers, not only to label carefully the terminals of their apparatus, but to send with each piece of equipment instructions for connecting up as well as for its care and operation. These instructions are usually accompanied by a well executed picture of the motor, showing how the terminals are located, each terminal being carefully marked and connected to a starting box similar to that shown in Fig. 1, which represents a series motor. However, as the terminals of various makes of motors may be brought out differently, a representation of the connections of one make may not apply to another, unless certain simple rules are followed. When it comes to this, the picture may be dispensed with and a diagram used as in Fig. 2. There is one thing necessary, the diagram must represent the motor it is used for; that is, if the motor is series wound, the diagram must represent a series motor as the one in Fig. 2; if it is shunt wound, it must represent a shunt motor, etc.

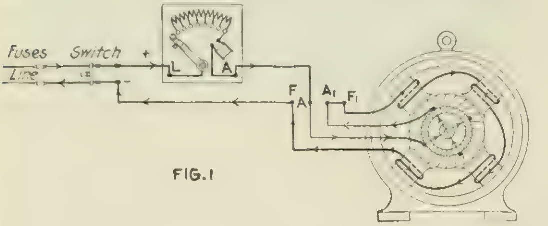


FIG. 1

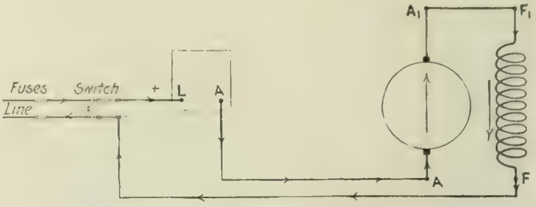


FIG. 2

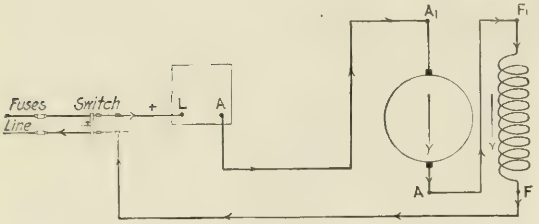


FIG. 3

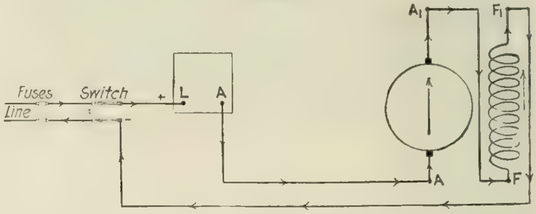


FIG. 4

POWER

Series Motor

To connect up a motor from a diagram, first determine which are the armature and which the field terminals, and what kind of a motor it is, either by inspection or by testing. Assume a condition as in Fig. 1, where the two center terminals represent the armature circuit; as can be seen, they come from the brushes and are marked *A* and A_1. The two outside terminals are the field and are marked *F* and F_1.

A good practice in connecting up a motor from a diagram is to start from one side of the switch and work around to the opposite side. In this case, start from the positive side of the switch, which in Fig. 2 runs to the terminal marked *L* (sometimes marked "Line") on the starting box. After making this line connection, next in order will come the other terminal on the starting box, which is marked *A*. By referring to Fig. 2, it will be seen that one wire runs from this terminal to one of the armature terminals marked *A*, although in this instance, it could be any terminal on the motor as the machine is series connected and there is but one circuit through it. This is true only for the series motor, therefore, it is best to make a practice of connecting the machine according to the sketch. The following can be laid down as a hard-and-fast rule for any motor:

Connect terminal *A* (sometimes marked "Arm") on the starting box to one of the armature terminals only on the motor and this part will always be right. Next connect the other terminal of the armature to one of the field terminals, which, in Figs. 1 and 2, are shown A_1 to F_1, although A_1 could be connected to *F*. Finally, connect the remaining terminal *F* on the motor to the negative side of the switch. Now if the connections are traced out in Figs. 1 and 2, it will be seen that they both run the same; i.e., from the positive terminal on the switch to the *L* terminal on the starting box; from *A* on the starting box to the armature connection *A;* from the armature terminal A_1 to the field terminal F_1 and from the remaining field terminal *F* to the negative side of the switch.

In a diagram, such as Fig. 1, the connections may be so shown as to produce a definite direction of rotation, while that in Fig. 2 does not indicate any particular direction. After the motor has been connected up, however, and is working properly, all that is necessary in order to reverse the direction of rotation, is to interchange either the armature or the field connections, as in Figs. 3 and 4. By tracing out the current, it will be seen to flow as indicated by the arrows. In either case, the connections in Figs. 3 and 4 will give a different direction of rotation from that in Fig. 2.

Shunt Motors

What has been applied to the series motor can also be applied to any type of motor. In Fig. 5 is shown a shunt motor connected to a starting box. Every terminal on the machine and starting box is indicated in its proper location, but, as in the series motor, these connections can be shown in a diagram, as in Fig. 6. The starting box for the shunt motor, however, has three terminals on it, the object being to connect the field across the line at the instant of starting. This will be made clear by referring to Fig. 5.

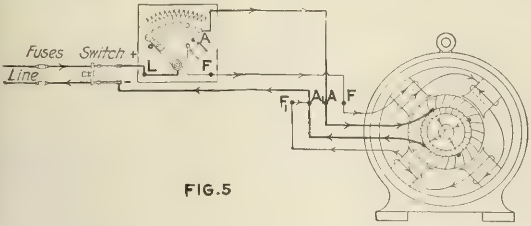


FIG.5

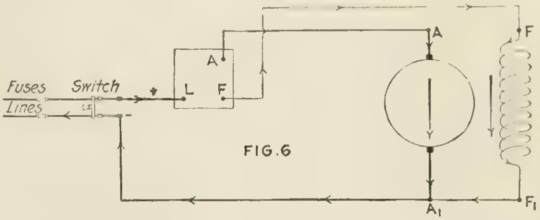


FIG.6

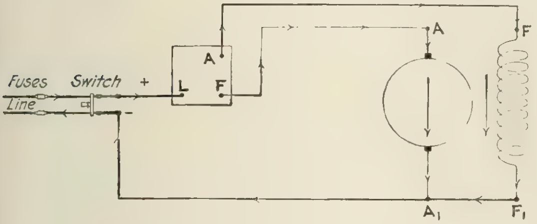


FIG.7

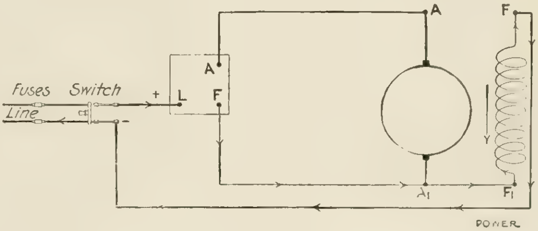


FIG.8

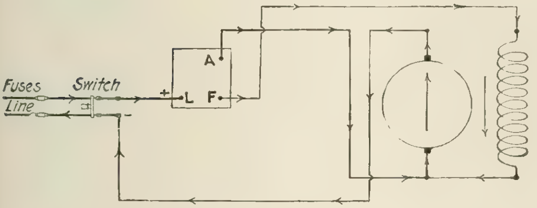


FIG.9

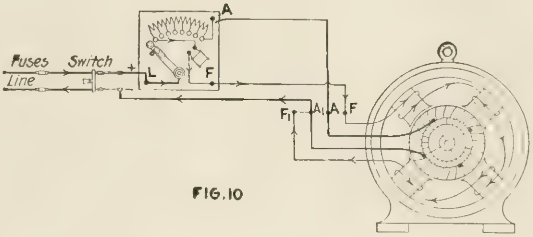


FIG.10

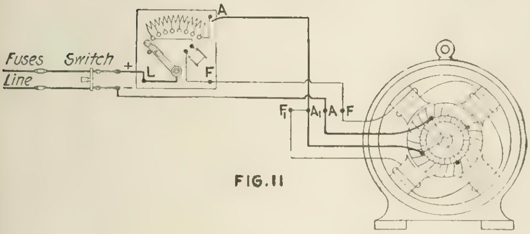


FIG.11

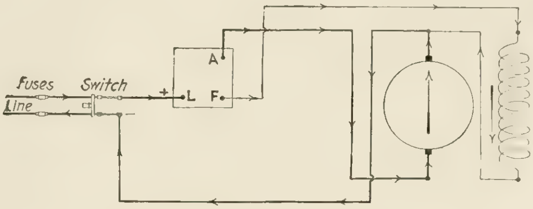


FIG.12

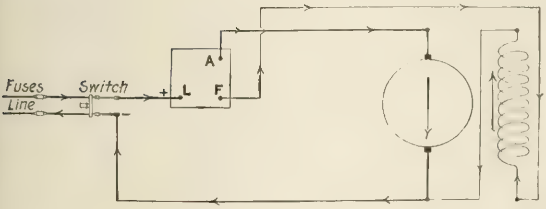


FIG.13

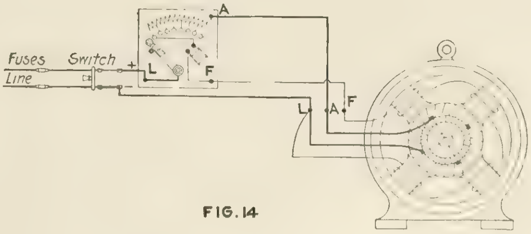


FIG.14

When the arm on the starting box is moved to the first contact of the starting resistance the field current will flow as indicated by the arrowheads; that is, direct from the line through the no-voltage release coil on the starting box to the field terminal F' on the motor, and through the field back to the line, thus applying full-line voltage across the field terminals at starting. This produces a maximum field strength, which develops a maximum starting torque for a given current in the armature. By tracing out the armature current with the starting-box arm on the first contact, it will be seen that all the resistance is in series with the armature and the current flows as indicated by the arrowheads. As the arm is moved over toward the no-voltage release coil, the resistance is cut out of the armature circuit and cut in the field. The starting resistance in series with the field has little effect, for the resistance of the field is so high compared with the starting resistance, that it is almost negligible. This additional terminal *F* on the starting box (sometimes marked "Field") does not greatly increase the complications of the connections, although more care should be taken in making the connections than in the series motor.

In the series motor the armature connections on the starting box could be connected to any terminal on the motor and be connected right; but not so for the shunt machine, the armature terminal on the starting box must connect to one of the armature terminals on the motor, and the terminal on the starting box marked *F* (or Field) must always be connected only to one of the field terminals of the motor, as indicated in Figs. 5 and 6, the remaining armature and field terminals being connected together and directly to the line switch. Care should be taken to have the motor connected properly before attempting to start it, as serious results may occur from wrong connections. For instance, if the connections were made as in Fig. 7, the field terminal *F* on the starting box being connected to the armature terminal *A* on the motor and the armature terminal *A* on the starter to the field terminal *F* on the motor. If the motor is started under these conditions, the no-voltage coil on the starting box will become very hot, and if left in circuit long enough, it would be burned out. If the motor was starting under load, the probabilities are that the coil would be burned out almost instantly.

Another mistake is that shown in Fig. 8; that is, the field terminal on the starting box is connected to the armature and field on the motor and the field connection on the motor to the line switch. By tracing out the current it will be seen that the fields are across the line, but both armature terminals are connected to the starting box. This will give full voltage across the field, but zero voltage across the armature, and the motor will not start; although, if the arm of the starting box is thrown over against the no-voltage release coil, it will be held there. No serious results would occur from this connection. Such mistakes are not likely on the large motors, as the field terminals on the starting box and motor are too small to receive the large wires of the armature and line.

One of the most common errors in connecting up a motor is that shown in Fig. 9. The armature terminal on the starting box is connected to one of the armature and field terminals on the motor and the remaining armature terminal of the motor is connected direct to the line. A shunt motor thus connected will start with a good torque at the instant of starting; that is, when the arm of the starting box is moved upon the first contact the current can flow from the positive side of the line through the field and the armature and back to the opposite side of the line and give full field strength. The armature current also flows in the direction indicated, and as far as the starting torque is concerned, it will be about the same as that when the motor is connected properly. As soon as the armature begins to turn, it generates a counter electromotive force. Since the field is in series with the armature the counter electromotive force will decrease the effective voltage across the field and, as the starting resistance is cut out, and the motor speeds up, the field becomes weaker and the motor races. If the motor is started under load there is danger of the starting resistance being burned out, for instead of the starting current becoming less as the motor comes up to speed, it becomes greater, and by the time two or three points of the resistance are cut out, the starting box is very hot or the fuse has blown.

After the motor has been connected, it is advisable to make a test to see that there have been no mistakes in making the connections. This can be done as follows: After everything is in readiness to start, disconnect the armature connection on the starting box as in Fig. 10, then close the switch and bring the starting-box arm on the first point. If the motor is connected properly, as in Fig. 10, the field circuit will be complete and will be indicated by a spark if the starting-box arm is allowed to drop back to the off position or the switch is opened. Care should be taken not to open the circuit too quickly, as this induces a very high voltage in the field. If the arm on the starting box is brought over against the no-voltage release coil, it will be held in this position until the switch is open or the arm forced away from the coil.

With any other combination of connections, the field will be open-circuited if the armature connection on the starting box is open, as in Fig. 11, which is the same connection as in Fig. 9. This will be indicated by the absence of a spark, as when the starter arm is pulled back from the first starting contact to the off position, although the open circuit in the field may be tested for in the same way if the motor is connected up properly.

Connecting up a shunt motor from a diagram, as in Fig. 6, involves no particular direction of rotation, but, as in the series machine, after the motor has been connected correctly, and is found to operate properly, the direction of rotation may be reversed by interchanging either the armature or the field connections, as in Figs. 12 and 13, respectively. Fig. 12 shows the armature connections interchanged; Fig. 13, the field connections interchanged. The connections in Figs. 12 and 13 will cause the armature to turn in the opposite direction to that shown in Fig. 6. It will be seen that although the current has a different direction in the field and armature in Figs. 12 and 13, the motor is connected the same as in Fig. 6, and this is the only possible connection that can be made and have the motor operate properly.

A mistake that is often made in attempting to interchange the armature connections to reverse the direction of rotation is to interchange the armature connection with that of the line, which is the same as that in Fig. 9, and will, therefore, produce the same results as explained for that connection. Care should be taken always to remove the jumper between the field and armature connections and to connect it to the opposite armature connection with the line wire. This mistake is often made on machines which have their leads connected to three terminals, as in Fig. 14. Under these conditions, the easiest way to reverse the machine is to interchange the armature leads at the brushes although either the armature or the field leads may be interchanged at the terminals inside the field frame.

⁂

The Goal of Boiler Designers is to obtain the largest number of pounds of steam to each pound of metal in the boiler. The various studies and experiments have clearly indicated the advantage of the use of a longer flameway between the fuel bed and the end of the tubes, giving an opportunity for completing the gas reaction before the products of combustion enter the flues.—"Railway Age Gazette."

Editorials

The Foot of the Ladder

Now is the harvest time for the annual crop of college graduates. Among them are thousands who have acquired engineering degrees. To those of the latter who have had a particular interest in and have specially studied the various branches of science pertaining to power generation, these remarks and our cartoon this week are addressed.

Throughout the four or more years of your school and college preparation you have had a more or less distinct goal in view. From time to time since your childhood you may have changed your ideas as to what you intended to be, but now you have probably made a definite choice. And with this has come the roseate vision of *your* future.

Like the youth in the sketch, you may have imagined yourself the designer or the operator of a big plant, or may have dreamed of some other equally worthy accomplishment. To you whose eyes have been fixed on the top is coming a painful awakening when you realize that there are other rungs in the ladder, particularly at the bottom and that there is no royal road or aëroplane path to the top. You must climb every inch of the way, unless you have a "pull" that enables you to skip some of the lower rungs (and then you are more to be pitied than congratulated). That parenthetical statement is made advisedly; what you miss by not passing through the fundamental stages can never be made up to you in later experience.

Assume then that you are obliged to begin at "the foot of the ladder," and have taken a "job" in a power plant. One of the first duties assigned to you may be such as that being given to the chap in the picture: "Go polish the hand rails on number three." This seems much beneath you. You cannot quite reconcile it with your dreams and you may, and justly, inquire of yourself: "Is it for this I have taken a college course?"

Yes, and no! You did not need thermodynamics to know how to polish hand rails nor higher algebra to oil an engine, but because of your mental training those menial tasks will, or should, take on a greater significance. You understand better than the untrained helper that neatness in the appearance of an engine room is only an index of a corresponding orderliness in every other detail that makes for efficient power-plant operation.

You see beyond the oil holes and grease cups and have some conception of the relation between lubrication and the reduction of friction. You already know that the object of a cool bearing is not a matter of temperature but of preserving the rubbing surfaces in best condition, so that the heat units in the fuel, so expensively turned into force, are not needlessly wasted in friction work.

If you will but sense it, this period when you are engaged in the simplest of plant labor is one of rare opportunity to be observing and thinking over what you see. There is plenty of time for taking notes (mental, if not written), as to conditions as you find them, why they are as they are, how they might be improved.

Do not make the mistake of thinking that others have already worked out all the problems that there are to solve. History proves the contrary. Ten years ago the advances that have been made in that time were unbelievable. A decade before that steam engineering seemed to those then engaged in it as near the ultimate as it did at the end of that ten years or does now. No, there is very much yet to be done and, as experience has shown, every time perfection is in sight some revolutionary improvement renders all previous practice obsolete.

Further, it has been demonstrated that those whose discoveries and inventions have amounted to the most were those who did not despise the little things. The slow process of working up through the lower grades made them mindful of the importance of details, for every big thing is only the combination or result of a host of details.

So we would say to those just beginning, count nothing as too humble for your best endeavors. Be ready and willing to perform the most menial service required of you. If in no other way, it will be invaluable in character building such as will make possible of realization those dreams you dreamed under your study light.

Commencement, as the name for the exercises marking the completion of a college course, is no misnomer. Of a truth it was most wisely chosen if it helps to impress on the proud recipient of the diploma that passing his examinations was as nothing to what he must do before the world confers any honors.

Another Coal-Saving Chemical?

Ever since the days of Kemkom there have been attempts, sincere and otherwise, to increase the heating value of fuel by a chemical admixture. Not so long ago engineers will remember that common salt or oxalic acid, disguised with coloring matter, was exploited to be mixed with ashes to be again used for fuel. The claims made were so extravagant as to be absurd, but, nevertheless, it had considerable publicity and sale. The latest announcement of an outbreak of this desire to get something for nothing appeared in the *New York Herald* under date of Apr. 29, in part as follows:

> A demonstration of a chemical composition recently perfected by a group of Canadian chemists was made yesterday in the boiler rooms of the Grand Central terminal. Officials of the New York Central R.R. were the spectators. The new chemical, a soluble crystal of secret composition, is poured over the coal, and, according to its discoverers, it increases the natural one part carbon and one part oxygen of the coal to one part carbon and two parts oxygen, the perfect state of combustion. The increased heat, it is declared, burns that portion of the coal which ordinarily is lost in the ashes.
>
> From 10 to 20 per cent. of the coal used in boiler rooms and factories and 50 per cent. of that used in households can be saved by means of the composition, the originators say.

A sample was procured by us for analysis (as in many similar cases) in order to learn the truth. The following is the report of the chemist:

Nature of Material—Composed of colorless crystals and a black powder, the resulting color being very dark gray. All is soluble in water except the black powder.

Loss on drying at 105 deg. C.	0.7
Insoluble manganese dioxide (MnO_2) (black oxide of manganese)	2.2
Potassium chlorate ($KClO_3$) (chlorate of potash)	64.4
Undetermined and loss, mainly sodium chloride (NaCl) (common salt)	32.7

It is the opinion of this laboratory that this material can have no practical value in saving fuel. The potassium chlorate will, on heating, liberate oxygen and promote combustion. The amount liberated, however, would not be enough to have any practical effect in saving the fuel when burned on a commercial scale. A pound of this substance would yield about as much oxygen as would be contained in from 15 to 20 cu.ft. of air, and as air costs nothing, it is much more logical to use the oxygen in the air for combustion than to use that from the powder.

In view of the foregoing, it is no surprise to learn that the results of two tests by the New York Central failed to verify the claims of the promoters. The absurdity of the whole thing is so apparent that further comment seems superfluous.

*

Encouragement for the Oil Engine

The greatest handicap to the general adoption of the oil engine in this country has not been its comparatively high first cost nor its mechanical difficulties, but the continually increasing price of fuel oil. Therefore, it is gratifying that the recent action of one of the great oil-refining interests may result in reducing the price of that commodity to a point where the high efficiency of the oil engine may be realized to advantage.

This possibility has been brought about by the decision not to purchase crude oil below eighteen degrees Baumé (0.948 specific gravity) for refining purposes. California and Mexico produce large quantities of crude oil of asphaltum base, high in sulphur but containing little gasoline or the lighter distillates, that evidently is considered as offering insufficient pecuniary reward for distillation. In California alone, about seven hundred thousand barrels of such oil is produced each month. Engines have already been developed to utilize these oils and further development seems assured.

Gratifying though this announcement may be for the oil engine, there remains a fact that may retard its general adoption; a fact that makes it difficult to reconcile the abandonment of refining heavy crude oils. Crude oils rich in gasoline and light distillates make an excellent fuel oil after the gasoline and light distillates have been removed, and if the profit in refining lies in the amount of gasoline that can be extracted, it would seem that the residue could be marketed at a correspondingly low price for use in oil engines. Instead of this, the price of the "fuel oil" residue has mounted as steadily and as rapidly as has the price of gasoline, the explanation being that the residue was too valuable to sell as such and that further distilling was a pecuniary necessity, the profit from the heavier byproducts being such as to fix the price of the fuel oil.

Logically, this should place a comparatively high value on the heavy asphaltum-base oils which it is claimed it will not pay to refine. The heavier byproducts could be easily distilled and the asphalt should find a ready market. It would appear, then, that the oil engine has been discriminated against ever since its advent, and that even now, when it would seem about to receive fairer treatment, the respite may be but temporary. The value of the heavy distillates of petroleum may suddenly increase in value—an increase that may occur without any apparent increase in demand or in curtailment of supply. Some equitable and binding agreement between the refinery and the oil engine is demanded by the economic situation of the day.

*

Indicator Diagrams

The first letter on the opposite page refers to a Green-Corliss engine which was erected in a certain city twenty-seven years ago, and had never been indicated until last March, when the diagrams shown were taken. The engineer made all his valve adjustments entirely by sound.

This engineer says he is a busy man and does not have time to read engineering papers or books. How successfully he has applied his native skill is evident and creditable, but it is apparent that the performance of the engine could be improved and less steam used.

As a man's handiwork reflects his predominant characteristics, let us consider these as characteristic "indicator diagrams" of the engineer as well as his engine. Lead or admission into an engineering society or association should have been earlier; more lead would improve both the head (think) and the crank (work) end. This is most noticeable at the head end, as a higher steam line or achievement nearer to that possible (boiler pressure) should have been attained. The steam or energy line does not hold up well, and is carried further before cutting off than would have been necessary had not the pressure been wire-drawn or throttled.

The point of cutoff is not sharp and well defined; the dashpot (or dash) seems faulty; the expansion line is not as good as it should be. The exhaust would be more free and the back pressure or resistance be less if adjustments were made. With a little more steam (knowledge) compressed at the head end, the cushion would be better and the machine would operate more smoothly with fewer shocks. All these adjustments could be easily accomplished by a little reading and mixing in the association. Lead could be acquired with high achievement, and good expansion by such improved head work.

The crank or work end is better developed, and is more consistent, although improvement at the head would also influence the crank. Then the performance of this human machine would be excellent.

*

Suppose that you are dissatisfied with Power. Suppose your butcher, your baker and the candlestick maker do not meet with your approval. In the latter supposition you take quick action; you tell them so. Power can only take the standpoint that you are satisfied with it, when you say nothing. This is your paper as well as ours. Let us have your frank criticism; in return we will publish the paper that *you* want.

*

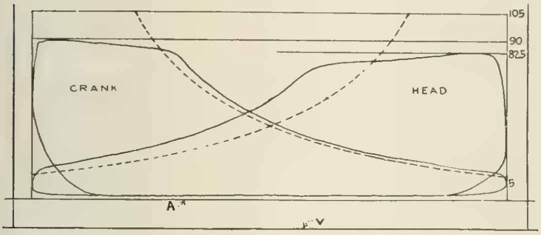
In all probability there would be less discontent by power-plant employees if the management would take them into its confidence as to the cost of upkeep, depreciation and general running expenses. A general understanding that all is not profit outside the fuel and labor charges should have a wider dissemination.

Correspondence

Valve Setting by Ear

Considering all the circumstances, the indicator diagram herewith is somewhat remarkable. It was taken from a Green-Corliss engine, 27 years old, which had never been indicated before. The same man who set the engine up is now running it. He never saw an indicator from that time until one was applied recently to take this diagram. In the meantime, he has set his valves entirely by sound, and in the light of that fact the diagrams from the two ends are well balanced and the events not at all badly timed.

The engine has a single cylinder, 16 in. in diameter, by 36-in. stroke and runs at 70 r.p.m., using steam at 105-lb. boiler pressure and exhausting to the atmosphere. The scale of the spring used in the indicator was 60 lb. The diagrams integrated show a total of 247.96 hp., the head end giving 130.12 hp. and the crank end 117.84 hp., so that neither is far from the average of 123.98 hp.



Diagrams from Engine with Valves Set by Sound

H. L. Smith.

New York City.

⁂

Lead Boiler Gaskets

Mr. Hawkins' letter in the issue of April 28, page 604, recalls my experience with such gaskets.

The plant had three O'Brien safety water-tube boilers of 535 hp. each. Lead gaskets, similar to the ones described by Mr. Hawkins, were made and used for several years with good results except that many of them would leak every time a boiler was allowed to cool down. However, most of the leaks would take up when the boiler was steamed up again, and the ones that failed were stopped by tightening up.

Taking the cost, etc., into consideration, they were satisfactory until we began using boiler graphite; then our troubles started. One man was kept busy stopping leaks, and frequently a boiler would have to be cut out when they could not be stopped.

On close inspection I found that some kind of chemical action was decomposing the lead in places.

The only cause to which I could lay this trouble was the graphite, and as excellent results were obtained from its use in the boilers, the lead was discontinued and jointless asbestos gaskets were found satisfactory.

These gaskets will last almost indefinitely when they are not disturbed, and they can be taken out and put back from 10 to 15 times, if given a liberal coating of flake graphite. It was necessary to use a new lead gasket every time a plate was removed, and to renew them every three or four months whether the plates were removed for other purposes or not.

W. A. Johnston.

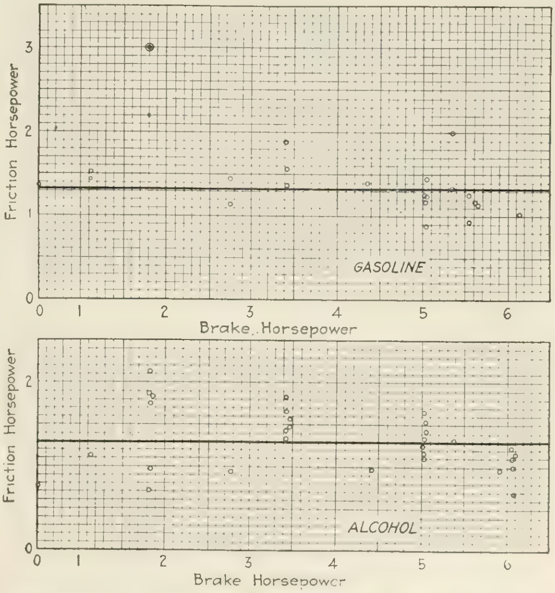
Pine Bluff, Ark.

⁂

Friction Horsepower

Robert Thurston was the man who affirmed that the frictional horsepower of a steam engine is practically constant at all loads. It is so considered in most textbooks, but it does not appear to be as generally known in relation to gas or gasoline engines, although the writer can see no reason why one should judge otherwise, provided the running conditions are right.

After comparing various test reports the rule is shown to hold as well for internal-combustion engines. Papers by C. H. Roberston, in the *Transactions* of the A. S. M. E., Vol. 21, page 396, and Vol. 22, page 612, show this to be true for a 125-hp. gas engine.



Comparison of Friction Horsepower with Gasoline and Alcohol

The points on the diagram herewith are plotted from Bulletin 191 of the United States Department of Agriculture. Gasoline and alcohol were burned in the same engine, and a comparison of results should therefore be interesting. With gasoline, the average energy consumed by friction was 1.317 hp., whereas with alcohol 1.305 hp. was consumed.

One test with gasoline gives a frictional horsepower of three, which is so obviously wrong that it was not considered by the writer in averaging the power absorbed by the engine through friction. It is marked by a double circle.

One can, therefore, rightfully conclude that with normal speed, lubrication and water circulation, the friction horsepower of any internal-combustion engine should be fairly constant regardless of fuel and load.

W. F. Schaphorst.

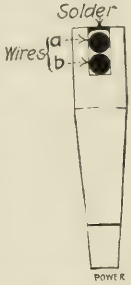
New York City.

⁂

A Centrifugal Effect

In one form of single-phase induction motor, a centrifugal device opens a switch that normally is used to close an auxiliary winding which enables the motor to start three-phase from a split-phase starter. In another form of induction motor, centrifugal effect is utilized for moving a ring that short-circuits the commutator bars at a certain speed above which the machine operates as a squirrel-cage induction motor. It is rarely, however, that centrifugal force is accidentally applied to make operative a motor that otherwise would not be.

A 20-hp., 500-volt, bipolar motor was belted to a small compressor that stored a tank used for charging air-brake reservoirs on electric cars. At starting and up to about one-half speed, a vicious spark traveled around the commutator, indicating an open-circuited winding. Above a certain speed, sparking ceased. Investigation showed the condition indicated in the accompanying sketch.



Commutator Ear

Each commutator ear had two coil leads connected to it. In the one that was the seat of trouble, the bottom conductor *b* had good soldered contact with the ear; the top conductor *a*, however, was suspended between the bottom conductor and a solder cap still intact in the upper part of the ear and without making contact with either. At all speeds below a certain value, this condition obtained; but above this speed, centrifugal force threw conductor *a* outward until it made contact with the soldered cap in the slot; all sparking then ceased as there was no open circuit.

J. A. Horton.

Schenectady, N. Y.

⁂

Feed Heating by Live Steam

In his excellent article, in the Apr. 28 issue, Mr. Braucher argues in favor of live-steam heating of the feed water on the grounds that hot water takes up heat more readily than cold. This is undoubtedly true, but it is possible to carry the explanation still further.

The heat of the fuel is transferred to the water in the boiler largely by conduction and convection. Particles of water in contact with the metal surfaces are heated by conduction; they then diffuse among the other particles and cause the whole to become heated by convection.

The transfer of heat from the metal surfaces to the water depends largely upon the velocity with which the water flows over the metal; the greater the number of particles brought into contact with the metal in a given time, the greater will be the amount of heat carried away, assuming a definite difference of temperature between the water side and the fire side of the plate. But the rapidity of motion is not the only consideration; diffusion or the spontaneous mingling of the molecules is also a factor even while the water is still and without currents.

Now, the ease with which the molecules of a liquid will move over and among the other molecules of the same liquid depends upon its viscosity, which in reality is a measure of the internal friction of the molecules. In a material like tar, the viscosity at ordinary temperatures is very high; that is, the friction of the molecules is so great that the tar flows sluggishly. On the other hand, an oil like gasoline has a low viscosity, so that it flows easily and rapidly.

A viscous liquid, if heated, becomes less viscous and flows more readily. This fact has a practical application in some plants that use crude oil as fuel. At low temperatures certain crude oils are so viscous that they will not flow through pipes and can be pumped only by the expenditure of considerable energy. To overcome this drawback, steam coils are inserted around the suction pipe in the oil tank. The heat of the steam so lowers the viscosity of the oil that it can be pumped readily.

What is true of tar is equally true of water. The viscosity of water at ordinary temperatures is greater than that of boiling water, which means that the molecules of boiling water meet with less resistance in moving over one another than do the molecules of cold water. Here, then, is a plausible explanation of the gain obtained by heating feed water with live steam. The heat derived from the steam increases the temperature of the feed and at the same time lowers its viscosity. The result is that the convection of heat both by circulation and by diffusion is made more rapid, because the molecules slide more easily over one another.

In corroboration of this may be cited experiments on the rate of heat transmission through tubes to water flowing through them, as in surface condensers, which were carried out in the laboratory of Owens College (Great Britain). The results of these experiments showed definitely that the amount of heat transmitted in a given time per unit area of heating surface was appreciably increased by heating the water. Some of the values from these experiments are tabulated herewith. It is interesting, first of all, that the velocity of the water was the same in all three experiments. The ratio of the viscosity to the density of the water, however, decreased markedly as the temperature of the metal surface was raised and the water was more highly heated. As the change of density is small with the rise of temperature, the rate of decrease of viscosity is practically that indicated by these ratios.

RESULTS OF EXPERIMENTS ON HEAT TRANSMISSION

Temperatures, Deg. Fahr.					
	Cooling Water				
Surface	Initial	Final	Rise of Temperature	Velocity of Flow Ft. per Sec.	$\frac{\text{Mean Value of Viscosity}}{\text{Density}}$ for Cooling Water
125.0	99.5	107.3	7.8	9.7	0.0000071
108.6	83.0	90.4	7.4	9.7	0.0000086
82.8	57.3	64.0	6.7	9.7	0.0000116

The range of temperature—that is, the difference between the initial temperature of the water and the temperature of the metal surface—is practically the same in the three cases. But with the higher initial temperature of the water, the rise of temperature was 7.8 deg. as compared with 6.7 deg. with the lower initial temperature. As the heat transmitted is proportional to the temperature produced, the increase in the amount of heat transmitted in the first case is

$$(7.8 - 6.7) \div 6.7 = 16 \textit{ per cent.}$$

greater than in the last case.

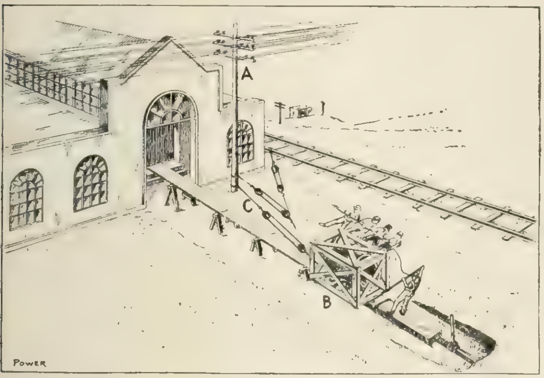
The case of a steam boiler is similar, in that the water moving over the plate or tube surfaces has its temperature raised by the heat of the hot gases on the other side. It is reasonable to assume, therefore, that the increased temperature causes decreased viscosity and results in a more rapid transmission of heat from gases to water. In other words, the gain derived from heating feed water with live steam is due to the water being brought into a condition in which it will receive heat more readily and transmit it more easily and quickly to the water in other parts of the boiler.

R. T. Strohm.

Scranton, Penn.

Heavy Hauling with Block and Fall

Recently the writer had to unload a 300-kw. rotary converter from a coal car and move it about 125 ft. across the power-station lawn and then up an incline of 3½ ft. in 30 ft. into the engine room. This converter was shipped in two pieces, crated on skids, the frame, base and polepiece or field coils being in one crate and the armature in another. The writer had only four men to help him and two screw jacks and three sets of ¾-in. rope falls and plenty of plank and blocking. The sketch will explain how we were able to do the job.



Showing Arrangement of Tackle

A telegraph pole *A* is located just beyond the door into which I wished to put the machine, and *B* represents the load. First we hitched the working or stationary block of one set of double-rope falls to the load *B* and after separating the blocks as far as the hauling line would permit, made the other block fast to the dead line *C*, the other end of which was fastened to *A*. The traveling end of another set of double-rope falls was made fast also at *A*, and with a catspaw hitch we fastened the other block to the hauling line of set No. 1. The traveling end or block of a third set of double-rope falls was made fast to the end of the drag line of set No. 2, and the other end fastened to a rail of one of the side tracks leading into the car barn. The rig was then ready to test. The men took up the slack and the writer put a bar behind the armature and by taking short nips could help the men on the start and before long we had the machine where it had to be turned to go into the station. It required considerable changing of hitches and shortening up on the dead line and drag lines, but we got the armature where we wanted it.

After we got the machines turned and headed up the inclined track into the station another problem presented itself. That was to hold the load while we changed the hitches, and after some thinking we adopted the following method. A hole was dug near the machine and on the same slope as the track into the station. One short plank was placed against the opposite bank of the hole. This was for an abutment for the lever jack. Then with a few pieces of blocking between the load and the jack we could get the strain on the jack and hold the load until we could get the falls rearranged ready to move along another 10 ft. or so. The writer cannot recommend this rig for speed, but where there is but little help and no crane it saves a lot of back ache and sweat and will enable a very few men to do the work of four or five times their number.

W. E. Chandler.

North Adams, Mass.

Draft Gage

My experience is that the draft gage leads all the rest of the boiler-room instruments in importance, at least when burning liquid fuel under variable load.

With liquid fuel, the steam pressure controls the oil pump, which makes it possible to reduce or increase the volume of fire under the boiler almost instantly. There is no bed of hot coal to check the admission of cold air to the hot shell in the event of the fires being suddenly reduced. It is, therefore, of the utmost importance that the draft be kept under more rigid control than in coal-burning plants.

Operating with damper regulators obviates much of the loss occasioned through load fluctuations, but it is almost impossible to set the damper regulators unless draft gages are used in this connection. One on each boiler will save the cost of the gage in a short time. For instance, in our plant when both boilers were in use, the draft gages read the same, but when only one was on, the gage on the other registered 0.1 in. The dampers were found to be tight. Finally, it was discovered that the wall dividing the boilers was cracked, thereby allowing cold air to flow not only through the boiler out of service, but also through the one under fire. Any engineer will appreciate what the loss might have been.

Whenever it is noticed that the draft gages are varying, the first procedure is not to reset the dampers without first investigating the cause of the variations. A little judicious "nosing around" will generally disclose cracks and air leaks. The application of a little asbestos cement mixed with liquid silicate of soda to such cracks will usually allow the gages to read the same without any adjustment whatever.

The writer adjusts the dampers to give a good working percentage of CO_2 for every position, using an Orsat for checking. By noting the oil pressure at the time the checking is done, it is easy to so set the dampers that there will be given an almost uniform condition of combustion in the boilers for any given rate.

The draft gage is one of the cheapest instruments to install and is, in the writer's opinion, the most important.

William Plaisted.

Redondo Beach, Calif.

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Accident to a Blowoff Valve

The extract from a paper by S. F. Jeter, on "Boiler Inspections," on page 619, May 5, mentions the blowoff valve as a fruitful source of danger, particularly when placed in a closely confined space. This recalls an experience of mine some years ago.

The boiler (of which I had just taken charge) had a brass stop-cock on the blowoff pipe—one of those with the plug cast hollow to save brass. Between it and the boiler was an asbestos-packed cock.

The operating space, about 3x3 ft., was inclosed on three sides, and on the fourth, the means of exit was either over or under the blow-off pipe. Using kerosene brought the scale down very fast, so that when the blowoff was opened, only a little steam and water issued from the pipe. I closed the cock, to work on it later when I had more time.

Soon after the cock was closed, there was a rattling sound in the pipe, followed by a loud report, and the brass plug was smashed. Fortunately, I had placed a wrench in position on the asbestos-packed cock and was able to close it.

An examination of the brass cock showed that the hollow plug had been crushed in as if struck with a hammer. My theory is that closing the brass cock caused a vacuum in the pipe, aiding the steam pressure to force the obstruction and causing water-hammer.

Basil Copping.

Kankakee, Ill.

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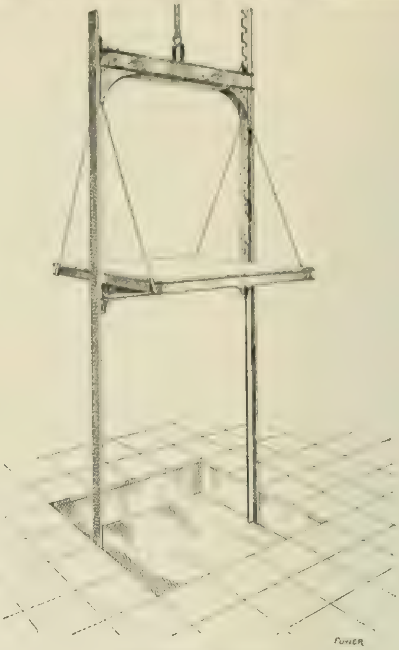
Safety Device Could Not Hold

The writer was called to look over an elevator, the safety catches of which had failed to work on the previous day. It was condemned by the inspector, ordered overhauled and put in safe working order.

The car was lowered to the basement, a 30-in. prop placed under the platform in a vertical position, and the cable slackened enough to allow about 1-ft. drop. The stick was then knocked out from under the platform, and the car dropped about 1 in. It hung suspended by the safety catches with the cable slack. The trial was repeated with the same result.

We were told a stick 18 in. long had been used by the inspector so the test was repeated with a prop that long, but the catches failed as on the previous day. What was wrong? The car was run up and the guide rail examined. It was found that smooth rails had been used on each side at the bottom up to a point just above the beam of the car. While the car was in the basement the rails could not be seen. The smooth rails were taken off, and toothed rails put on. These old rails had been in use for many years, and had not been noticed until the inspector, for lack of a longer stick, had picked up the short one by chance. Had he followed the custom of other inspectors by testing at one of the upper floors the safety device would have acted.

Some elevators have smooth guide rails and friction clutches to grip them in case the cable breaks; in others, even a rough, corrugated, eccentric-shaped, safety gripping device is worn away from lack of lubrication, and is not capable of the least resistance to prevent a car falling to the basement. Cars should be tested each day, the safeties kept in constant operating condition and all defects discovered if possible before the accidents occur.



Smooth Rails

R. A. Cultra.

Cambridge, Mass.

⁂

Pump-Packing Troubles

I had considerable trouble with the water-end packing on a small boiler-feed pump of the plunger type. In the daytime, when the pump handled return water at about 180 deg., there was no difficulty, but during the night, when cold water from the city mains was used, the pump cooled and the glands leaked badly. The night man would tighten them up in the evening and slack them out in the morning. This was sometimes forgotten in the morning, and the hot water would expand the packing and cause excessive friction and wear.

To overcome this, live steam was piped to the receiver of the pump and throttled just enough to keep the temperature about the same as during the day shift. This was easily done, because the demand for water at night is practically constant. After making this change the plunger and piston-rod packing lasted almost twice as long and reduced the friction considerably; this also prevented excessive loss of water.

A. R. Kummerer.

Hazleton, Penn.

Value of Laboratory Coal Testing

There are some important features affecting the value of laboratory tests on coal. A proximate analysis in which moisture, volatile combustible matter, fixed carbon and ash are determined by methods that are more expeditious than accurate, should only be relied upon when the general character of the coal has been previously established by more exact and rigorous methods.

In any case, the chemical analyses only establish the fact that the coal contains the elements hydrogen, carbon, sulphur and other substances that are either inert or prejudicial. The hydrogen contained may not benefit in proportion to its percentage, for the hydrogen and oxygen present react, resulting in the elimination of hydrogen with the formation of water vapor, which absorbs heat, thus entailing a loss.

The proximate analysis does not indicate such a condition which can only be obtained by a strict quantitative analysis. Serious error may arise from some wrong procedure, either in securing the sample or some detail that would have important influence on the results.

Obtaining samples is too often entrusted to someone lacking practical judgment; while the sample itself may be representative in general, certain physical characteristics are lacking without which the results are practically worthless.

In collecting samples a man should note when a particular invoice is very much finer than the regular run. The chemist would never surmise such a condition from his results if his attention had not been directed to it by a note or statement. It is highly desirable to have the chief engineer and the chemist coöperate in coal sampling and testing.

The engineer and his staff in their experience acquire a lot of knowledge in regard to the peculiarities of coal, and if there is a mutual interchange between the boiler room and the laboratory there is no doubt that much valuable data would be secured.

The matter of analyzing the ashes is important, for often it shows the fact that considerable coal is going to the ash dump when not apparent by observation.

T. H. Reardon.

Pittsfield, Mass.

[See also the editorial on coal analysis which appeared Apr. 14 and the letter by C. J. Barton on page 640, May 5, which are along the same general lines.—Editor.]

In reply to C. J. Barton's letter, in the issue of May 5, under the above caption, I will say that too many engineers and others underestimate the true value of the laboratory test when properly done by a competent man. The only way to buy coal is on the B.t.u. basis; then you pay for what you get and not for what someone else says you get.

In making our contract for coal every year we specify that each pound must contain so many B.t.u. For instance, last year the guarantee read 13,400 B.t.u. and 8 per cent. ash, at $2.20, and the ashes hauled away from the plant. This last item, prior to making contracts stipulating the B.t.u. and ash, cost us 6c. for each ton of coal burned, which would make our cost price $2.14 per ton. The way we arrive at the final figures is this: Multiply the actual B.t.u. by the cost per ton and divide by the number of B.t.u. guaranteed.

Supposing a sample drops to 11,500, which is often the case, it would work out thus:

$$11{,}500 \times 2.14 \div 13{,}500 = \$1.836$$

instead of $2.14, or a saving of over 30c. per ton, or a lump sum of $61.20, in one month, which is no small saving, besides the satisfaction of knowing that we pay for only what we get. The following is the form on which the analyses are reported:

LABORATORY OF W. J. RATTLE & SON
33 Commercial Bank Building
Cleveland, O. 7-1-13

For..........
Sample of Coal Received 6-28-13.
B. L..........
Boat..........
Tons..........
Dock..........

	Per Cent.	
Moisture	1	37
Volatile combustible matter		
Fixed carbon		
Ash	13	17
Sulphur		
Phosphorous		

Calorimeter Test

B.t.u. (dried at 212° F.).......... 13,038

Analysis by William Rattle

Now the ash problem will work out similarly, only in a smaller ratio. A man must keep abreast of the times, but to do this, it is not necessary to adopt any fads or fancies. There are some things that are absolutely necessary today which did not exist 15 or 20 years ago. All owners of isolated plants look for better results than they did a few years ago, for they are frequently told that they can buy current cheaper than they can manufacture it. One way to keep the central station out is to put your plant on as economical a basis as possible and buying coal on the B.t.u. basis is another.

O. Newton.

Cleveland, Ohio.

*

Gage Hand Jack

The hand jack illustrated is an improvement over the various types now on the market, its special feature being that the screw cannot be clogged with dust and dirt, it has no sharp corners, and, therefore, can be carried in the pocket.

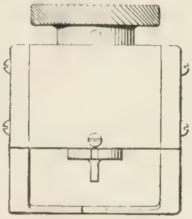


Fig. 1.

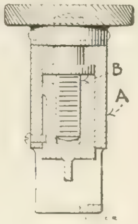


Fig. 2.

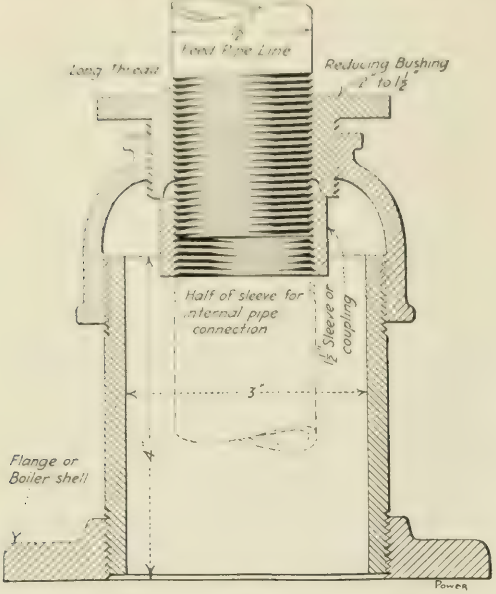
Fig. 1 is a side view and Fig. 2 a section, showing how the sleeve A protects the feed screw B.

Ernest Schwartz.

Bronx, New York City.

Troublesome Pipes

Feed and blowoff pipes often fail at their junction with the boiler. The method of connecting shown has proved satisfactory. The fittings used are so familiar that an extended description is unnecessary.



FEED-PIPE CONNECTION

New Orleans, La. GEORGE SCHWESSINGER.

⁂

Cheap Labor?

Many columns have been devoted to boiler firing, and many are the good suggestions offered and scientifically explained, but I regret that they are not read and studied by the men who handle the shovel. To make this possible they would have to be printed in a foreign language, for most of the coal in this city is handled by cheap foreign labor.

To keep the payroll as low as possible seems to the proprietor the most economical, but it is not so. Where a new plant is installed on a guaranteed evaporation of water per pound of coal, the contractor runs his tests with first-class firemen, the best that can be had (at times engineers are engaged to fire the test). After the test is over and the owner puts in his 12 hr. and $2 a day men, the coal cost goes up, as do many other accounts. Yet he will still say that it is out of the question to pay competent men $3 or $3.50 per day to get the best rating of his plant, and complains to the chief engineer about the coal used.

The engineer knows it is useless to try to educate such firemen. He can discharge them, but the pay prevents his getting another class of men more competent. The payroll must be kept at the lowest point, and the owner thinks he is saving money. Central stations are gaining through this particular cause. It is time for the isolated-plant owner to wake up, take his engineer into his confidence, and find out how the plant can be conducted to show a big profit over the central-station figures. This has been demonstrated many times by owners who have placed their confidence in the engineer and given him a free hand to make it possible.

New York City. J. C. SCHENCK.

⁂

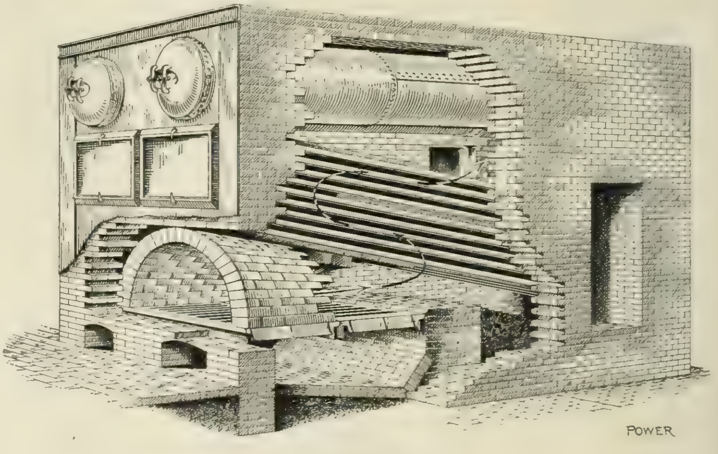
Fatal Tube Failure

An eyewitness gives the following description of a boiler-tube failure occurring nine years ago which cost the lives of four men. It never reached the press as the employees were pledged to secrecy on pain of dismissal.

The boiler was a so called high-pressure, water-tube, and was used for testing purposes. Steam for testing was often carried as high as 500 lb. to the square inch. When not in demand for this service it was used for ordinary steam making in connection with a battery of other boilers. The high furnace temperature incidental to such pressure and other severe conditions caused considerable trouble by overheating the tubes, several having been replaced because of signs of distress. To protect that part of the bottom row of tubes directly above the fire, a firebrick arch was built over the grate-bar space. This form of furnace proved disastrous, partly because no chance was had to watch the tubes while in operation.

In a short time after the test boiler had been cut off the line to run the steam pressure up to 400 lb., a bottom tube was ruptured. Just what the pressure was is not known. A subsequent examination showed that the tube had been badly bagged, probably for some time, as the metal was stretched extremely thin at the edges, and it had opened out almost flat for a distance of about 2 ft. The boiler front and furnace settings were almost completely wrecked.

The sketch will give an idea of how the arch was placed in the furnace. It would seem that after the brickwork got thoroughly hot the arch was not much protection.



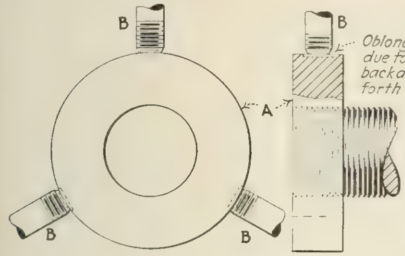
ARCH IN PLACE

Philadelphia, Penn. EDWARD T. BINNS.

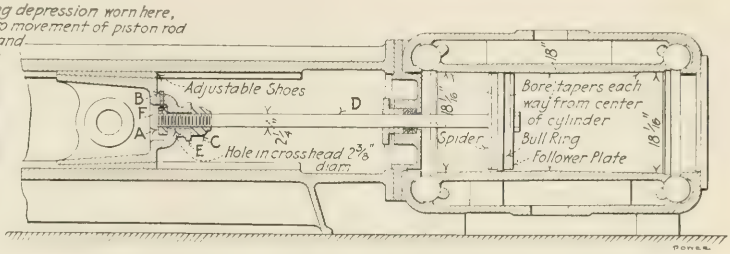
Unusual Construction and Wear

The foreman of our machine shop was sent to an engine plant to make repairs. The engine was an 18x42-in. Corliss, which had been running almost continuously for 10 years. The illustration shows the piston, the piston rod and the crosshead. The piston was 1½ in. and fitted with a single sectional packing ring. Each section of the ring was supported by a coil spring contained in a socket cored in the bull ring, holding it against the cylinder bore. The crosshead was bored out in the hub, not threaded, to 2⅜ in. diameter.

The piston rod was fastened with the nut *C*, and nut *A* screwed on the end. The three setscrews *B* screwed into the hub of the crosshead and against the nut *A* were undoubtedly meant for the purpose of alignment. On taking out the piston, it was found that the bore of the cylinder, although perfectly round, had worn in a regular taper from 18 in. at the center to $18\frac{1}{16}$ in. at either end, as shown, and also that a depression had been worn under the point of each setscrew. This led to the conclusion that one of the nuts, either *C* or *A*, must have become loosened, which caused the setscrews to wear the nut *A*, as shown in the detail. It could then move in any direction, allowing the piston to tilt and wear the cylinder as mentioned. The satisfactory method is to screw the rod directly into the crosshead and then lock with the nut *C*.



Detail of the Locknut


Oblong depression worn here, due to movement of piston rod back and forth
Adjustable Shoes
B
F
A
C
E
Hole in crosshead 2⅜" diam
D
2¼"
18 1/16"
18"
Spider
Bore tapers each way from center of cylinder
Bull Ring
Follower Plate
18 1/16"
POWER

Peculiar Connection of Piston Rod to Crosshead

C. R. Courtenay.

Watertown, N. Y.

⁂

An Interesting Steam-Engine Breakdown

The writer recently investigated the breakdown of a horizontal compound engine. The engine, mounted on the top of a locomotive-type boiler and fitted with a superheater and jet condenser, had been running for the greater part of the day under apparently normal conditions.

The first warning was severe hammering in the cylinders, and before the engine could be stopped the back low-pressure cylinder cover was smashed, both pistons were broken, the end of the piston rod was broken off and the cotter at the crosshead end of the rod was sheared through.

Such an accident is characteristic of water in the cylinder, but the question was, how could it get there? The condenser was located about 3 ft. below the center line of the cylinders and the air pump about 1 ft. lower than the condenser. The engine was coupled to the same shaft as a waterwheel to take the load at times of insufficient water. At this time the stream was in flood and it is probable that the waterwheel was taking more than its usual share of the load. The conclusion was that the engine was being pulled around and the low-pressure cylinder acted as a pump and produced a better vacuum than the condenser, lifting the water from the condenser.

There is an element of risk in coupling a waterwheel rigidly rather than through a free wheel. Such accidents would probably be prevented by placing the condenser as low as possible relative to the cylinder, fitting a nonreturn valve in the line and a float to break the vacuum as soon as the water rose above its normal level in the condenser.

C. H. Williams.

Manchester, England.

⁂

A Condensing-Plant Suggestion

A large number of plants in the Central states, where the rivers vary in height as much as 40 ft., have the condensing equipment located in pits several feet below the engine-room floor. This allows of water being furnished to the circulating pumps by gravity, but furnishes a more or less difficult proposition in disposing of the condensate, which is generally handled by single-stage centrifugal pumps. These pumps elevate the water to the surface into feed-water heaters.

The total head, including friction, is in many instances in excess of 50 ft. A pump handling water against such a head with a 28 or 29-in. vacuum must be at all times in almost perfect shape, as a slight leak at the suction side will suffice to stop the pumping action. Then it becomes quite a job to restart the water toward the heater. In the meantime the condenser is filling and the engineer is expecting a crash if a slug of water reaches the dry-vacuum pump. (The pumps in such installations are usually placed on the engine-room floor.) Water mixed with air in alternate slugs has no respect for the proverbial 34.5 ft. The air in the water expanding will cause the latter to be lifted several feet in excess of the theoretical maximum suction height. The dry-air pump is not free from danger of flooding, because it is over 34 ft. above the condenser.

In installations of this kind there should always be provided an emergency low-head discharge outlet near the pump. This outlet, provided with a seal, can be opened into the pit and temporarily relieve the condenser until the trouble is located.

John F. Hurst.

Louisville, Ky.

Engineers' Study Course

Elementary Mechanics--XI

LAST LESSON'S ANSWERS

46. The pressure on the part of the boiler head supported by the stay is

$$6 \times 9 \times 120 = 6480\ lb.$$

and this force acts at an angle of 90 deg. to the head. The sides of the triangle $ABCA$ (see Fig. 42) represent the three forces acting at the point D where the stay is fastened to the head of the boiler. If the stay was horizontal the pull would be 6480 lb., but since the stay makes an angle with the shell the pull becomes correspondingly greater. Let the side AB equal 6480 lb., or the force tending to blow out the 6x9-in. piece of the boiler head. The side BC will give the load on the stay and the side AC will represent the force tending to shear the rivets.

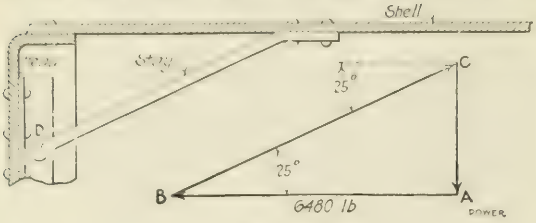


FIG. 42.

$$BC = \frac{BA}{cos\ 25\ deg.} = \frac{6480}{0.906} = 7152$$

Therefore, the pull on the stay-bolt is 7152 lb.

47. Let the weight W be placed at the point E, midway between the points A and B (see Fig. 43). A vertical line drawn through the point E will bisect the line AC at the point D. The vertical force acting at the point A and at the point B will equal ½ W, since W is located at the center of the line AB. Consider the point A as a free body, as shown in Fig. 43. The side MN of the triangle $MNOM$ is drawn horizontal and represents the thrust in the strut AB. The side ON is drawn vertical and equals ½ W while the side OM is drawn parallel to AC and represents the pull in the tie-rod AC. The angle OMN = 30 deg. Therefore, the side OM or

$$T = \frac{\frac{1}{2}W}{sin\ 30\ deg.} = \frac{500}{0.5} = 1000\ lb.$$

Likewise the side MN or

$$P = 1000 \times cos\ 30\ deg. = 1000 \times 0.866 = 866\ lb.$$

Hence the tension in the tie-rod is 1000 lb., which is just one-half of what it was when the weight W was placed at the end of the bar AB.

48. There are three forces acting at the point B, namely, the vertical force ½ W, the horizontal pressure in the strut or 866 lb., and the reaction of the pin B. The resultant of the horizontal pressure in the strut and the vertical load at the point B is the pressure acting on the pin B. Construct the parallelogram $BRSKB$ (see Fig. 43) with the side BR = 866 lb., and the side BK = 500 lb. The diagonal BS gives the direction and magnitude of the pressure acting on the pin B. Thus

$$BS^2 = RS^2 + BR^2$$
$$= 500^2 + 866^2 \text{ (since } RS = BK = \tfrac{1}{2} W)$$
$$= 1{,}000{,}000$$

or

$$BS = 1000\ lb.$$

Also the $sin\ x = \frac{500}{1000} = 0.5$, or angle x = 30 deg. Therefore, if the diagonal BS is extended backward it will pass through the point D since the angle DBE = 30 deg. = the angle x. It is to be noted that the point D is the point of intersection of the line of action of the weight W and the line of action of the pull in the tie-rod AC. Hence the direction of the pressure on the pin B might have been determined directly by drawing a line through the points D and B, as explained in Lesson V, under the solution of problem 20.

Still another method of finding the magnitude of this pressure is as follows: Construct the parallelogram $DHFGD$, letting the diagonal DF = the weight W (to scale). Then the side DH represents the tension in the tie-rod AC, and the side DG represents the pressure on the pin B. It is evident that the triangle $DFHD$ has all its sides equal since all its angles are equal, or DH = DG = DF = 1000. Therefore both the tension in the tie-rod and the pressure on the pin B are equal to 1000 lb. The force producing equilibrium at the point B is the reaction of the pin B, which is equal and opposite to the pressure BS, shown in Fig. 43.

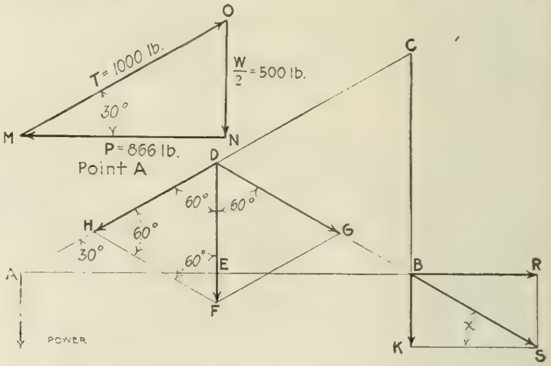


FIG. 43.

49. There are four forces acting at the point A (see Fig. 41, last week's lesson), namely, the weight of 4000 lb. acting downward, the pull of 3500 lb. in the hoisting cable AC, the unknown pull in the tie rope AB, and the unknown thrust in the boom AD. In Fig. 44, let OG equal the weight of 4000 lb. and let OH represent the pull of 3500 lb. in the hoisting cable; let OR represent the direction of the resistance offered by the boom, and OS the direction of the resistance of the rope. Under

the action of these four forces the point A remains at rest and the forces are in equilibrium. Hence the direction and magnitude of the forces may be represented by the sides of a polygon taken in order. Now construct a force polygon by drawing the line OG vertical and making it equal 4000 lb. to an assumed scale; from the point G draw the line GK parallel to the force OH (which is the tension in the hoisting cable) and equal to 3500 lb. to the same scale as OG; from the point K draw the line KM parallel to the force OS (which is the unknown pull in the tie rope). Now extend the line RO until it intersects the line KM at the point M. The line MO is then the closing line of the polygon $OGKMO$ and gives the direction and magnitude of the resistance exerted by the boom to counteract the load acting upon it. By measurement the line KM is found to equal 3350 lb. and the line MO equals 8950 lb.

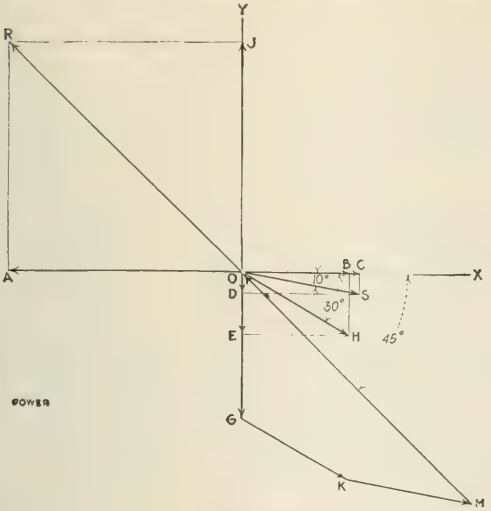


FIG. 44.

This problem may also be solved analytically by resolving all the forces into their horizontal and vertical components, as shown in Fig. 44. Thus OC is the horizontal component, and OD the vertical component of the force OS. Next apply the laws of equilibrium as stated in Lesson X, under Case III. The ΣH and ΣV must equal zero, thus,

$$\Sigma H = OS \cos 10 \text{ deg.} + OH \cos 30 \text{ deg.} - OR \cos 45 \text{ deg.} = 0$$

$$= 0.985\,OS + 0.866 \times 3500 - 0.707\,OR = 0$$

or

$$0.707\,OR = 0.985\,OS + 3031$$

and

$$\Sigma V = 0$$

$$\Sigma V = OR \sin 45 \text{ deg.} - OS \sin 10 \text{ deg.} - OH \sin 30 \text{ deg.} - W = 0$$

or

$$\Sigma V = 0.707\,OR - 0.174\,OS - 0.5 \times 3500 - 4000 = 0$$

or

$$0.707\,OR = 0.174\,OS + 5750$$

Hence

$$0.985\,OS + 3031 = 0.174\,OS + 5750$$

or

$$0.811\,OS = 2720$$

and

$$OS = 3353 \text{ lb.}$$

Substituting this value of OS in the equation above and solving for OR there results,

$$0.707\,OR = 0.174 \times 3353 + 5750 = 6334$$

or

$$OR = 8957 \text{ lb.}$$

Therefore the pressure on the boom is 8957 lb.

50. The value of the pull in the rope was found to be 3353 lb.

By this time, if the student has carefully followed the text and the solution of the various problems given from week to week, he should be able to apply the principles studied to the solution of many problems that constantly face him in power-plant work. Lack of space forbids the solution of all the classes of problems that might arise.

The next few lessons will take up some of the applications of Statics to the simple machines, such as levers, balances, pulleys, etc.

As a final help to the student the following four rules are given for the solution of any and all problems either in Elementary Mechanics or any other subject.

I. *Think.*
II. *Analyze.*
III. *Equate.*
IV. *Solve.*

STUDY QUESTIONS

No advance study questions will be assigned this week, but as a substitute the student is urged to review the problems of the previous weeks, and to master any points which he has failed to grasp.

*

Beating the Central Station

By E. O. HAMILL

Some time ago the writer accepted a position as engineer in a manufacturing plant which was operating its machinery with induction motors and purchasing current from the city light and power company. There were 10 motors in the factory, ranging in capacity from 1 to 50 hp., and, as might be expected, the light and power bills were exceedingly high. I was satisfied that the power could be produced much cheaper than the company was buying it, but in attempting to induce the company to install its own power plant it became evident that not one of the management was familiar with engineering subjects and all were averse to spending money for a new plant.

The establishment was a woodworking factory, and to dry the lumber and heat the building in winter it was necessary to install a boiler. This had been done, and as the factory had only been built for about three years the boiler was still in good condition. It was of the fire-tube type rated at 150 hp. and built for 125 lb. steam pressure. This gave ample capacity, and it only remained to get an engine and generator.

Formerly the company had been located in a near-by town and at that time had a plant of its own, but due to the poor service obtained from the engine it was left behind when the change was made to the new location. An investigation showed that this engine had been well preserved and would require very little fixing to put it in good running order. A report on this matter was finally presented to the directors, who decided to let me have the engine.

About 75 per cent. of the power was consumed in the milling department, which was all in one room, the machines being operated by three motors, one 50 hp. and two 35 hp. each, belted to a line shaft which ran the full length of the room. As the engine had a center crank, I decided to run a belt from one side to the line shaft in the milling room, and a belt from the other side to a small generator for furnishing current for the lights and small motors in other departments of the factory. The engine was of the balanced slide-valve throttling type, and in the old factory had been operated at 150 r.p.m. After rebabbitting the main bearings the eccentric strap and the crosshead shoes, planing the valve and its seat, turning up the piston rod and putting in a new valve stem, I equipped the engine with a good oiling system and placed it on a substantial concrete foundation. I then speeded it up to 200 r.p.m., ran it for two hours, and then put on the load. It has run without a hitch ever since.

The next thing was to obtain a generator. The engine was already operating the machinery in the milling department, so that there was no further use for the three large motors. By a piece of luck I succeeded, after some correspondence, in getting a second-hand, 40-kw., alternating-current generator complete with exciter, switchboard and instruments, in exchange for the three motors. The generator was as good as new and had only been used a few days. It had been purchased by a contractor who, in placing the order, had specified the wrong voltage, and the owners were unable to use it. The generator was wound for 230 volts, so that it was not necessary to use a transformer. The motors operated on 220 volts, and the lights on 110 volts. By using a balance coil on the lighting circuit I was able to install a generating set at very small expense.

Instead of live steam the exhaust was used for heating, and the steam pipes, which formerly had been bare, were covered. Last winter the plant was operated on less fuel than it required in previous winters for heat alone. No extra help to care for the plant was needed as the company had always employed a licensed engineer. The saving is apparent. The company has simply obtained its power free, which means from $250 to $300 per month, as this is what the bill was when purchasing current from the lighting company.

During the summer months when no heat is required in the factory the plant can be operated on 1800 lb. of coal per day of 10 hr. if coal alone is used. At times, however, the refuse from the woodworking department is almost sufficient to keep the boiler in fuel. The coal costs $2.15 per ton delivered. The total cost of installing the plant, including labor, all of the material for the foundation, belts and other equipment, was a fraction over $400. The company saved this amount in two months' time.

*

Side-Pusher Electric Locomotives are used on the Cleveland ore docks of the Pennsylvania R.R. They do not run on the same tracks as the cars they move, but on parallel 42-in. gage tracks at one side. Each carries a triangular side-arm frame on trunnions and this is raised to clear or lowered to engage the corner or pole plates. Energy is taken from two protected rails lying inside the running rails.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Great combustibles' Is the fireman coming to his own" on page 791 you'll find out just what such engineers as Captain Manning, George Diman, L. E. Moultrop and F. W. Dean think of the importance of the efficient boiler-room force. By ding, the fireman rides in the first hack and the engineer is tagging on the rear of the procession.

*

A kind publisher sent us an advance review on "Complex Hyperbolic and Circular Functions"—but neglected to send the book. We would like to believe every word he says about this entertaining and sprightly little book, but we dassent print the review. Nobody can put one over on us until we first get a squint at the complexity of his hyperbole. No, sirree!

*

"Passionsfestspielpenkrauterklostterdelicatessenstuckskaese" is the name of a new cheese. This may be all right for a new cheese, but just suppose some grease maker took it into his poll to wish such a name on his product. Oh, limburger!

*

A certain Connecticut town, intending to increase its water supply, will "build a watershed covering about 50 acres." One of the town officials, a building contractor, who naturally favored the "shed," has been severely criticised by a fellow townsman thusly (or pretty nearly thusly): "'Twill be a 'tarnation shame, by heck, ef Ezekiel Billin's gits ther job of puttin' a shed over fifty acres of water! I'm agin it, tooth an' nail. Zeke's got sufficient outen ther town already!"

*

A Chicago man named Hellmuller didn't like his name, for some reason or other. It's a perfectly good name, but it was too hot and too long for Hans. The court told him he could cut the "hell" out of it, and the chopping began that minute. Hope that the Himmelreiches won't follow suit, won't be anything left out there but Chicago—and there are folks who don't believe in an intermediate state.

*

Nine hundred and twenty-five feet of "Aquitania" will soon bump into our shore. She's really 901 ft. over all, but the evident patriotism of her British owners has tacked a 24-ft. lion on her prow, thus making her longer than the "Imperator." The latter lost her eagle in a recent storm. Looks like the open season for eagles and lions, so here's how to 'em both!

*

Dear Billy Spills: Does anyone besides myself, when by myself, get "beside himself"?

C. O'TWO.

Sometimes, I'm beside myself,
And the other self is Me—
Me and I can't seem to glimpse
All things as they should be.

Me sometimes agrees with I,
Then I thinks the same as Me.
Now and then, it is the case
That we both will disagree.

I and Me should get together—
Dwell in gentle amity.
Me's the best friend that I've got,
I should think a heap of Me!

*

Every now and once in a while some G. Washington Wellwisher manifests his kindly interest in "Power" by sending us a clipping or a suggestion, but he does not sign his name. "Power" wants to thank brother Wellwisher by letter, at least. Don't be so 'tarnation modest. You make us feel that we can't pay our debts.

*

Here's a case in point of anonymity: "C. O. S." writes that the English "smoke-abatement bill makes it incumbent upon the owner, OCCUPANT or user of a furnace to have it consume its own smoke. It seems to me that the composition of the 'occupant' of a furnace has much to do with the smokelessness. Some 'volatile' individual would probably cause the furnace to emit much smoke, but 'fuel' like me (and composed principally of carbon, capped with ivory) would smoke but little, or not at all."

Inquiries of General Interest

Best Time for Blowing Off Boiler—What is the best time for blowing off a mill boiler?

C. H.

In the morning before the fire has been started up, as much of the sediment in the boiler will then have settled to the bottom of the shell and will pass out when the blowoff cock is opened.

Ventilated Fire-door Frames—Why are boiler fire-door frames sometimes made with holes extending through the frames, all around the fire-door openings?

D. E.

The holes are intended to serve as passages for air for cooling the dead plate, jambs and arches of the fire-doors and for supplying the air thus warmed to the top of the fire.

White Lead vs. Graphite for Pipe Thread Joints—For making screw-threaded steam-pipe joints, is it better to use white lead and linseed oil or graphite mixed with cylinder oil?

J. W. D.

For steam joints a "dope" of graphite and oil is preferable to white lead and oil, more especially because joints made up with graphite can be drawn up with less friction, and when required, can be unscrewed easier.

Sloping Bottom of Combustion Chamber—What is the advantage of filling and sloping the floor of the combustion chamber behind the bridge-wall in a return-tubular boiler setting?

E. D. G.

The principal advantage is in affording greater convenience for cleaning the combustion chamber by drawing the soot down the sloped floor to the cleaning doors.

Size of Neutral Lead—In a three-wire direct-current system why is the neutral lead often made the same size as the outside leads?

L. F. B.

The neutral is generally made the same size as the outside leads to comply with the National Electric code, which permits a fuse to be dispensed with if the neutral wire is of the same size as the outside wires and the neutral is grounded. The objection to the use of a fuse in the neutral lead is that if the fuse should blow when the load is unbalanced, the side of the system carrying the smaller load will be subjected to excessive voltage, which might be great enough to blow out the lamps.

Inches of Vacuum for 1 lb. Absolute—How many inches of vacuum are equivalent to 1 lb. per sq.in., absolute pressure?

J. W. S.

Taken at ordinary temperatures about 2.04 in. of mercury column is equivalent to a pressure of 1 lb. per sq.in. As "inches of vacuum" signifies the amount which a pressure is less than atmospheric pressure expressed in inches of mercury, then for any particular case the inches of vacuum equivalent to 1 lb. per sq.in. absolute would be the height of the barometer in inches, less 2.04 in.; for instance with a barometer reading of 29.2 in., a pressure of 1 lb. per sq.in. absolute would be equivalent to

$$29.2 - 2.04 = 27.16 \text{ "inches of vacuum."}$$

Loss of Power from Slipping of Belt—When there is slipping of a belt on a driving pulley, how is it explained that the per cent. in loss of power is the same as the per cent. of belt slipping?

J. F.

In belt transmission the number of foot-pounds per minute delivered to the driving pulley equals the peripheral speed in feet per minute multiplied by the net resistance of the belt in pounds, taken as the difference between the tension of the tight and the slack side of the belt; while the number of foot-pounds of useful work which the pulley transmits to the belt equals the velocity of the belt in feet per minute multiplied by the number of pounds of difference in tension of the tight and the slack side of the belt. Hence when slipping exists the useful work transmitted to the belt will be less than the useful work applied to the driving pulley by the same percentage that the velocity of the belt is less than the useful work applied to the driving pulley by the same percentage that the velocity of the belt is less than the peripheral velocity of the pulley or "percentage of slip," and this difference in energy is lost as it is employed solely in overcoming the friction which is incident to the slipping of the belt.

Natural Gas Compared with Coal—How many feet of natural gas would be required to obtain the same heat as from one ton of coal?

S. W. R.

The average natural gas has a calorific value of about 900 B.t.u. per cu.ft. and good grades of coal have an average calorific value of about 14,000 B.t.u. per lb. Therefore the complete combustion of one ton or 2000 lb. of coal would yield

$$14{,}000 \times 2000 = 28{,}000{,}000 \text{ B.t.u.}$$

so that with equal perfection of combustion about

$$\frac{28{,}000{,}000}{900} = 31{,}111 \text{ cu.ft.}$$

of average natural gas would be required for obtaining the same heat as from one ton of coal.

Safe Pressure for Boiler Joint—What would be the safe boiler pressure per square inch, as based on the longitudinal joint with a shell 78 in. in diameter, the thickness of the plates being ¾ in., their tensile strength 55,000 lb. per sq.in. of cross-section and the efficiency of the joint 89.8 per cent. of the solid plate?

M. W. C.

The strength of the solid plate being 55,000 lb. per sq.in. of cross-sectional area then the strength of the joint for 1 in. of its length would be

$$1 \times \tfrac{3}{4} \times 55{,}000 \times 89.8 \text{ per cent.} = 37{,}042.5 \text{ lb.},$$

and allowing a factor of safety of 5, the joint would have a safe working strength of

$$\frac{37{,}042.5}{5} = 7208.5 \text{ lb. per in.}$$

of its length. The diameter of the shell being 78 in., the resistance required across 1 in. of length of the joint would be equivalent to the boiler pressure per square inch exerted on

$$\frac{1 \times 78}{2} = 39 \text{ sq.in.},$$

and the joint would, therefore be suitable for a working pressure of $7208.5 \div 39 = 184.8$ lb. per sq.in.

Allowable Working Pressure on Stay-Bolt—What would be the maximum allowable boiler pressure per square inch for 1⅛-in. diameter screwed stay-bolts having riveted-over ends and pitched 4¾x4½ in.?

W. M.

The outside diameter of the stay-bolts being 1⅛ in. = 1.125 in., then with 12 V-threads per inch their diameter at the bottom of the thread would be

$$1.125 - (\tfrac{1}{12} \times 1.732),$$

or

$$1.125 - 0.1443 = 0.9807 \text{ in.},$$

and the net cross-sectional area at the bottom of the thread would be

$$0.9807 \times 0.9807 \times 0.7854 = 0.755 \text{ sq.in.}$$

Allowing 6500 lb. per sq.in. of cross-section, the allowable load per stay-bolt would be

$$6500 \times 0.755 = 4907.5 \text{ lb.}$$

As the cross-sectional area of the stay-bolt at the bottom of the thread is 0.755 sq.in., and the pitch of staybolts is 4¾ × 4½ in., then the net area supported by a stay-bolt would be

$$(4\tfrac{3}{4} \times 4\tfrac{1}{2}) - 0.755 = 20.62 \text{ sq.in.},$$

and the allowable pressure would be

$$4907.5 \div 20.62 = 238. \text{ lb. per sq.in.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Boiler-Room Practice

The last meeting of the Engineers' Club of Boston was devoted to the above subject, a discussion of which was introduced by the following paper by Captain Charles H. Manning, of Manchester, N. H.

I have been invited by our Committee on Meetings to talk this evening on "Boiler Room Practice," presumably of the present day or the uptodate practices, and to arrive at that point I purpose to go back to my first experiences and sketch at random some of the changes that have developed in my more than fifty years of life among boilers and fire rooms.

Late in 1861, the breaking out of the civil war having prematurely ended my course in engineering at the Lawrence Scientific School, I started in to learn the trade of machinist at Charles Reeders' Engineering Works at Baltimore, my native city.

A POWER PLANT IN THE SIXTIES

My first job, as the last new apprentice, was to run the power plant of the establishment, which plant consisted of a locomotive boiler of about seventy horsepower located in a "leanto" being as naked as it came from the boiler shop; and an engine that it was hard to find because enveloped in a cloud of steam from leaky joints and stuffing boxes, that located it, and that was all. One of my chief duties was to wheel sufficient coal from a frozen pile some hundred or more feet away and out of doors, to keep up steam from seven a.m., till 6 p.m. That first fireroom job gave me a respect and consideration for a coal heaver that few of you have.

The boiler seams were of the lap single-riveted type, no butt straps, leave alone the "sawtooth" double-butt-strap of today. There was no double pop safety valve but a single, old-fashioned lever valve with a lever long enough to hang a spare shovel on to increase the pressure in time of stress. The blow and check valve chambers were made onto the boiler with cast-iron borings and sal ammoniac driven joints. There was no water gage, but three gage cocks, which I well remember, as the joker of the shop opened one of them down the back of my neck, much to my discomfort and to his sorrow.

THE FIRST SHEET OF ASBESTOS PACKING

There was no automatic damper, steam flow meter, superheater, economizer, fan blower, induced draught blower, automatic stoker, CO_2 recorder, automatic feed regulator, feed water heater; except that the engine exhausted into an open tank from which the feed was supplied. The hand-hole and manhole joints were four-strand plaited gaskets, for though sheet rubber had come into limited use at that time it was too expensive for this purpose and it was not till a year later that I handled the first sheet of asbestos packing that was ever made. There was no steam flue cleaner but the old-fashioned rod with alternate iron and leather washers. There was, as may be inferred from what I have before stated, no automatic stoker fed from an overhead coal bin with automatic weighing apparatus in the down spout, nor ash conveyor. There was, however, a steam gage which if vigorously rapped would jump up or down if the pressure had varied since it was last rapped. The engine had no automatic cutoff and its speed was regulated by the throttle and steam pressure, and there was no forced-feed oiler but a good squirt can.

Now I do not claim that this was an uptodate plant at that time, but it was the power plant of a shop that built marine beam engines up to cylinders of 90-inch diameter and 12 feet stroke which, with the moderate pressure in use, gave about 500 hp. Contrast some of these things with the "boiler room practice" of today and, of course, that practice is much controlled by what we have to practice with. Where shell boilers are to be used the nature of the longitudinal seams is the first thing to be considered. It goes without saying that they must be double-butt-strapped seams, but shall they be triple or quadruple riveted with the inside strap broader than the outside or shall they be sawtoothed straps of the same width? I fail to find any mention of the latter in the preliminary report of our Committee on Boilers, notwithstanding the support it has received from eminent authority within the society.

Whether the power boiler is to become a thing of the past, to be succeeded by the internal-combustion engine, which is fast coming into its own, is a conundrum I will leave for our younger members to find the answer to.

In the boiler room today we find hot surfaces covered with some nonconducting material, and the question between the many is whether the more expensive ones save enough over the cheaper grades to pay interest and sinking fund expenses; and there are many other holes in this skimmer, on both sides of it. Hair felt is the best as it has the largest percentage of air spaces, and that is what counts; true while it lasts, but its life is very short. I have found a good quality of asbestos cement, not mud, the most profitable in my experience. Pop safety valves we find in all modern plants, and their design has been a matter of much refinement, but from the nature of the service reliability is the first quality to consider, and this means simplicity of construction, and the twin valve, much used in the marine service, with one locked so that it cannot be monkeyed with, will fill all the requirements of the uptodate plant.

We find today on all boilers a glass water gage and gage-cocks, and some engineers insist on a constant use of the gage-cocks which, as long as the water bobs up and down in the glass, is worse than useless, for you know the passages must be free; but when the water in the glass becomes suspiciously still is the time to resort to the gage cocks. This holds true even with the latest refinement of automatic feed valves, for, though their purpose is to carry a more constant water level, the action in the glass should be the same. The saving of fuel accomplished by this device is negligible, but in a large battery of boilers where water tenders are employed it can make reduction in labor expense.

The water level is the most important item in boiler room practice, and I have always been a believer in employing a water tender whose sole duty was to see that the water level is kept at proper point, and he the only man allowed to touch a feed or blow-off valve. This is "Safety First," which has always been the corner stone of my belief.

The steam flow meter, one of the latest innovations, giving information as to how much the boiler is doing at the instant is a very valuable guide to the engineer.

A BAN ON THE HIGH CHIMNEY

In the matter of air supply for fires, we find either the direct blower or induced draught has largely superseded the immense and costly chimney with its heat-wasting propensity, and I think in the future we shall see very few chimneys built any higher than barely necessary to get rid of the products of combustion without offense. The capacity of a chimney being directly as its diameter and as the square root of its height, diameter is what we want, and where sufficient height cannot be allowed with the low temperature of escaping gases, resort should be had to exhaust fans, but better to an air-tight furnace with automatic stokers and blowers; for as soon as the pressure of the furnace gases exceeds that of the surrounding atmosphere, or becomes a plenum instead of a partial vacuum, we have burned-out furnace doors and a deadly atmosphere for the fireroom.

The correct draft arrangement is of the greatest importance to the designing engineer. Intimately connected with this in its operation is the CO_2 recorder or some other instrument of constant operation, that the operating engineer may know just what he is doing. To assist to this knowledge there should be syphons or other delicate pressure gages in the ashpit, the furnace and the flues. The practice of feeding boilers with any kind of water that comes handy—and if it disagrees with the boiler of giving the latter a dose of medicine to cure if possible—is rapidly disappearing, and the practice of giving the water the medicine first is progressing; it is the only right way to do. This practice, even to distilling every drop of makeup water that goes to the boiler when that is necessary, is bound to come.

THE FEED WATER QUESTION

The weighing or measuring by weir all water fed to the boilers, as practiced in many plants today, is a move in the right direction, for though having no direct bearing on operating costs except to slightly increase them, it gives a knowledge of what is actually being done, and therefore is useful. The feed water heater question is one of the live ones today, and the economizer is one part of it. Some designers claim that with steam-driven auxiliaries, the exhaust steam of which will furnish all the heat required for the feed water, it is better to omit the economizer and allow the gases to go off at a wasteful temperature of 500 deg. or over and so save in first cost of plant and care and upkeep of economizer, and that may be so, but I do not believe it. In the first place all the auxiliaries should be power driven, for it is certain that the power can be furnished at less cost from the main plant than it can be made in detail, and the lower the temperature of the escaping gases the higher the economy of the plant. Of course, there are modifying circumstances in every plant, and it is on these that the designer of the plant must use his brains.

With water-tube boilers the question of handhole gaskets has been solved by making ground joints, and better fittings and asbestos gaskets have solved most of the old-time sorrows on this point. Modern practice recognizes the importance of clean boilers inside and out, and for fire-tube boilers, both horizontal and vertical, the steam tube blower has been found very useful in cleaning the tubes daily or oftener instead of the older practice of once a week, and similar contrivances are in use with good effect on water-tube boilers. The internal scaling of water tubes and external scaling of fire tubes is another story, and a much more difficult problem, but the correct solution of it is to use water that makes no scale, purifying the water before it is fed to the boiler.

A GANG OF "MONKEYS" TO CLEAN BOILERS

At Key West, during the late unpleasantness with Spain, there were lots of little yachts with all kinds of boilers, usually firetube boilers with the tubes bent in all directions. These boilers were so small that a good-sized man could not get into them, and we used a gang of "monkeys" (darky boys) to clean them out. This gang of little fellows, under the direction of one overseer, was the best boiler-cleaning outfit that I ever ran, and they were the source of the only labor trouble that we had. They struck for one penny more an hour—and we gave it to them.

The only objection I know of to ash conveyors is that they hide what I want to see the first thing in going into a fireroom, the furnace refuse, as it is always the source of the quickest information as to what is going on in the plant. The recording pressure gage is one of the best features of the modern plant, and where the records are kept on file, as they should be, you have a ready and valuable record of what has been done, and the most valuable part of the Log which should be kept in every station.

HEIGHT OF THE FURNACE

Much has been written lately on the height of the furnace, with a very general tendency to increase this dimension, and for long flaming or highly bituminous coals this is right, but where anthracite is to be burned, especially with a boiler set in a brick casing, it is all wrong as it increases the opportunity for inleakage of air which is very destructive of economy.

The boiler plant for a textile mill to run fifty-eight or less hours a week must differ from that of an electric power company situated in a city where real estate is high. Coal pockets and automatic handling of coal; which in the latter case are a necessity, are generally costly luxuries in the former, as the fixed charges on the investment are going on all the time while its use is limited to a few hours a day. The practice today in the boiler room is to use a higher grade of labor and a stricter discipline, with closer supervision, till, from the old time go-as-you-please place that it was, it is now a place of military precision.

There is no doubt of the economy of a high rate of combustion, forcing boilers above their rating and using high superheat and a high vacuum, especially with the steam turbine in connection with the best surface condensers it is possible to purchase; and automatic stokers.

PURCHASING COAL BY B.T.U. METHOD

On the purchase of coal by the B.t.u. method I am still a heretic where a large plant is concerned.

A highly bituminous coal will give a very high B.t.u. value. When that coal is fired by hand and a shovelful first strikes on top of the fire, the hydrogen flashes off and you lose three-quarters of the value of the hydrogen in the coal. The best test of coal for hand firing is the fixed carbon. The coal with the highest fixed carbon will do the most work on a common hand fire. With bituminous coal the automatic stoker will give a higher average result, because, the coal being shoved under the fire, the hydrogen is distilled off gradually and you get the value of it. The advantages in labor saving are immaterial, but you get a better result with a coal with hydrogen in it than you can get with the best hand fire. Test the best coals on the market in one of the regular boilers used in every-day work, and, other things being equal, the fuel that evaporates the most water for the dollars is pretty sure to be the most profitable to buy.

With steam turbines the better vacuum you get the better results and the last inch or two is the most important. It is impossible with a jet condenser to get as good a vacuum as you can with a surface on account of the air introduced with the water. This would make no difference with a reciprocating engine, but the turbine is like a multiple-cylinder engine with a low-pressure cylinder of almost infinite size.

ECONOMY OF AUTOMATIC STOKERS

I once had a boiler-room foreman who was very much opposed to automatic stokers. I made him a proposition that he take a battery of ten boilers and run a 36-hour test on it, with the best firemen that he could pick. I would then run a test with the same kind of boilers, stoker fired for the same length of time, same coal, same weighing apparatus, same everything, but with stokers. The results of the trial were 15 per cent. in favor of the automatic stoker, with a net saving of about 10 per cent., after all the steam for operating fans, stokers, etc., had been charged against them.

CORLISS' LIMIT FOR PRESSURE WAS SIXTY POUNDS

The greatest change in fifty years is in the pressure of the steam. The ordinary pressure for stationary engines was 30 to 40 lb. In 1882, when I went to work at Amoskeag, I started to put in a pair of 2000-horsepower engines, and the question of boiler pressure was one of the uppermost things in my mind. I wanted to go to 150 lb. Mr. Corliss, with whom I talked it over, had been putting the pressure on compound engines at 60 lb., and Mr. Corliss assured me that anything over 60 lb. was bound to get me into trouble and was of no use. Steam gages were not made without a special order to record over 100 lb., and I settled down to 100 lb. pressure, not because I thought it was enough, but it was all that I could get standard pipe fittings, gages, etc. for. During the time in question pressures have gone from an average of 40 to 200, which is about high enough, because the gain from increase in pressure is in a decreasing ratio, and the difficulties increase very fast.

W. G. DIMAN, Superintendent of Power, Amoskeag Manufacturing Co., Manchester, said:

Very little of the energy contained in the coal reaches the switchboard, and when this is taken into consideration it signifies that a great deal depends on proper combustion. The first requisite in combustion is to get out of the coal all of the heat that it contains, to use as much of the heat as is possible for the generation of steam and as little as possible for nonproductive purposes. Taking the price of coal at an average of $3 per ton, a week's run will show quite a loss or saving, due to the kind of firing. There is more to be gained or lost in a boiler room than in any other part of a power plant and for this reason the boiler plant should be placed in charge of a trained or a technical man. About 70 per cent. of the cost of operation of power plants is chargeable to boiler rooms, and for the handling of this expenditure the management often employs the lowest grade of labor instead of giving inducements to the intelligent workman to stay in the boiler room and handle this expenditure judiciously. While working toward better power-plant management and looking for more efficient engineers, the boiler room has somewhat been left to care for itself, and in many cases the labor has been entirely unfitted for the care and operation of the plant. The waste in the average boiler plant is great, and a good part of it is preventable. The idea appears to prevail that it takes brains to run an engine room while just brawn is sufficient for the boiler room. Even the worst turbine operator cannot greatly decrease the efficiency of the prime mover, while in the boiler room the loss in economy due to ignorance or lack of suitable indicating and recording apparatus will run high. There is, as a rule, in every boiler house a chance for improvement, and you can generally find evidences of the lack of knowledge on fuel economy. Preventable losses exist in nearly every power plant. The general practice is to burn coal and to keep up steam at any cost. An average man generally operates the boiler house, and average firemen, who know only generally the art of firing, burn the coal regardless of the economical results. It is not the general practice to educate men to burn coal to the best advantage. A man may be a good fireman from the standpoint of safety and reliability, he may keep his surroundings clean and always have the steam up, but this does not prove that he is getting the best results out of the fuel.

COMBUSTION ENGINEERS FOR BOILER HOUSES

In time the practice will be to employ what may be termed combustion engineers to operate boiler houses and to gradually instruct the men under these engineers by constant supervision to become skilled in proper combustion work. It is always best to employ as expert firemen as is possible, for economy is the result and there is just as much reason, if not more, to use this class of men for regular running conditions as there is to look for such men to run tests.

We blame the fireman many times when he does not know, expecting too much from this class of men. Generally the kind needed cannot be employed at the wages paid firemen. Firemen are entitled to some instructions, no two plants are alike and no two boilers act alike unless they are made to do so. The methods pursued in one plant are different from those in places where men were previously employed. The combustion of coal, the load, draft and furnace equipment call for a method that perhaps could not be followed in any other boiler room. You have a license law in this state. Some parts of the license law for the firemen may be good I do not think, however, that one question is ever asked the fireman as to what he knows in regard to the proper combustion of fuel. Would it not be a benefit to the fireman as well as to his employer if he did know something of the running conditions inside the boiler as well as how to obtain the most economical results? In this manner he would be educating himself as well as being more valuable to his employer.

It is not a good plan to hold the fireman responsible until the foreman knows everything is all right himself, and this can best be obtained by recording instruments from daily running conditions. A fireman's duty is, as a rule, done when he maintains a level, even-burning fire of the correct height, regulates the draft to suit the load and fuel conditions, maintains a uniform water level and keeps soot out of the boiler. Finding air leaks, determining the proper height of fires and correct draft for load conditions is the combustion engineer's business. Firemen must use judgment, but fuel and load conditions in nearly every plant admit of finding what furnace adjustments are needed. Every fireman should understand that just as much fuel can be wasted by excess air coming through uneven and too thin fires as through an open furnace door. No one man can look at a boiler furnace and say exactly how near or how far it may be from its highest economy.

Steam boilers have been employed for 200 years, but less is generally known about them and their operation than the electrical engineer has found in 25 years about the practical forms of electricity. In the average boiler rooms the steam gage and water glass are about the only instruments that have been provided, or the only ones that have been paid any attention to by the firemen. No instruments showing the condition of the fires, the air supply, gases, etc., have been used to any great extent, and it is for this reason that so little is known by the average foreman and fireman. It is more important to consider as a part of the boiler equipment instruments that will show the water evaporated, coal burned, steam given out, and the furnace adjustments than to equip the prime movers with proper instruments, and more can be saved. With such instruments any local losses can be determined for elimination.

IMPORTANCE OF INSTRUMENTS IN BOILER ROOM

To the ambitious fireman instruments are as important in the boiler room as the indicator is in the engine room, except that they have the added advantage of giving continuous indication of the process of combustion. Every fireman should know the meaning of the different instruments and what each means to him. As a rule, at present they mean nothing for the simple reason that he has never been educated to understand them. If he had he might become more interested and try for better results. With reliable instruments it is within the power of every fireman to intelligently procure proper combustion.

The interest of the men must be kept up and some standard set to which they must work. This can only be maintained by the man in charge either through some form of bonus or by showing the fireman that by firing correctly with the assistance of the proper instruments his work will be better, with less exertion on his part.

Recording instruments are preferable as they show the average existing daily conditions, and make all tests one of weekly or monthly running condition, which is the only fair test to run. All charts should be closely examined daily by the foreman in charge so that he may note any discrepancy and can hold the man under him responsible for economical results. The majority of plant owners are willing to purchase instruments provided the fireman can show that he is familiar with the subject of combustion and fuel economy and can convince the management that through their constant use a check can be kept on the average running conditions and money saved thereby.

One of the best instruments for showing the general working conditions on an individual boiler is the steam flow meter. While these meters may not be absolutely accurate, so long as they give relative indications, they are a great help. If the fireman sees that his arrow goes up under certain conditions he knows that he is getting better results, and if he is at all ambitious he will soon learn what conditions will keep the arrow at its highest point.

The foreman must know what results give the best working conditions and he must run the boilers as near their rating as possible. A comparison should frequently be made between the rated capacity of the boilers and the running conditions as they exist to show whether the boilers are over or underloaded to meet the condition of best economy. When the boilers are run far below their rating the loss increases greatly. Peak loads are carried better by running the boilers temporarily above rating. With the Manning type of boilers an efficiency of about 72½ per cent. or over is obtained with capacities from about 68½ to 123 per cent. of the normal rating and the efficiency falls off rapidly after passing 125 per cent. of the rating. When a constant load is carried, only enough boilers should be run to carry the load at their normal rating. In many cases more boilers are run than is necessary or they are run more above rating than will give satisfactory economical results.

FEED-WATER AND DAMPER REGULATORS

Automatic devices are good so long as they remain automatic, but the more complicated you make any boiler and its appurtenances the more trouble you will have. Each device has its own merits, and each if given sufficient attention might prove satisfactory for a considerable length of time, but it is a question whether such devices would offset the operation of a boiler by a properly trained and educated fireman. There are many feed-water regulators on the market, some of which are satisfactory, but in a large plant where regular water tenders are employed the use of these regulators will lead to carelessness, and while they may work satisfactorily for a while, there may be a time when they will work disaster. Some of these regulators may give a steadier feed than hand regulation, but this must be offset by the safety element which such an automatic device cannot cover. In small plants where the fireman is the engineer, fireman, and general handy man a water regulator may be satisfactory, but in a large plant its use is questionable. There are balanced-draft devices on the market which give satisfactory results and border on meeting the ideal conditions of combustion, but such devices, like all others, mean constant vigilance. If the firemen are educated as they should be and we have trained men for the boiler house, then proper combustion can be obtained without the aid of automatic devices. Until this condition exists, boiler-room economy must suffer.

One important factor that is gradually coming into vogue is a signaling arrangement between the switchboard and the fire rooms. This is very important from an economical standpoint as the fire room must be kept informed of the load, any change in it or any anticipated change, so that the boilers may be properly run to cover the conditions. This is not always done.

NEW ENGLAND MILLS FIFTY YEARS AGO

GEORGE H. DIMAN, Consulting Engineer of the American Woolen Co., and father of the preceding speaker, said:

The mills in New England 50 years ago were run as follows: The kind of boilers used were plain cylinder boilers, about 30 inches in diameter, 30 feet long, with three set in a battery; this made one furnace. The gases passed underneath the shell and then to the chimney. Hognose boilers; two 15-inch flues passed through the center of the boilers and the gases passed part way underneath the boiler, and then to the chimney.

Anthracite coal was used exclusively; the sizes were steamboat, grate and egg, no bituminous coal being used. Millions of tons of small-size anthracite lay in the valleys of the Pennsylvania coal regions which nobody thought could be used, nobody reasoned that there was just as much carbon in a pound of this coal as in the larger sizes. These have since been cleaned up and burned.

Seventy-two to eighty pounds steam pressure was the limit. The appliances on the boilers consisted of three gage cocks, a steam gage and weight and lever safety valves.

Boiler makers in each city and town in the state were allowed to build the boilers as they saw fit. No attention was paid to economy of the steam plant. All they looked for in those days was to keep the mill going. The water was supplied through an open heater, using a pump to take the water from the heater to the boilers. The supply of water to the boilers was regulated to the supply into the heater, and many times through the carelessness of the fireman the heater was allowed to fill up, and the first thing they knew, the exhaust pipe was full and backing into the cylinder.

The engines were mostly Corliss beam engines, but just about that time they began to build horizontal engines. There was not an engine of over 1000 hp. running in New England. If there was a pair of engines, one cylinder was used condensing and the other noncondensing. All the piping was cast iron, and all the joints were put together with red lead putty. These were the conditions I found existing 50 years ago. The indicator was something unknown in mill practice, and I do not think that there was an indicator owned in a New England mill at that time. Mr. Frank Bacon, of Boston, did all the indicating.

About 1875 the mill men began to look for economy in the steam plants in New England, not paying any attention to the boiler room, and thinking all the saving was to be made in the engine room.

A HORSEPOWER ON THREE POUNDS OF COAL

Here is where I received my first encouragement. The mill had twelve horizontal tubular boilers and a pair of 30-in. x 6-ft. Corliss engines. The agent of this mill encouraged me in every way, and so did the assistant superintendent, Mr Walter H. Parker, now agent of the Pacific Mills. Still, we kept looking in the engine room for economy and utilizing the steam for manufacturing purposes. Here is where I assisted in making the first test of an engine. (I have the original letter with me this evening, and if any of the members wish to see it, they may do so.) Mr. Nathaniel Herreshoff, the famous yacht builder, was employed by Mr. Corliss as draftsman, and being a young man like myself at that time, and thinking it might please Mr. Corliss, we perhaps jockeyed the test a little. When I showed the report to Mr. Corliss (just to show you how honest he was in his dealings), he told me that when I went home I had better put that in a bureau drawer, and not show it to anyone; if his engines were producing a horsepower on 3 pounds of coal, he was satisfied. The reason he said this was that, taking a Midland steam report from England, the engines while being compounded were using from 10 to 14 lb. of coal per horsepower per hour. Of course, this was bogey coal—by bogey coal I mean the waste coal from the mines. Of course, you must remember that engines at that time in England were slide-valve engines, and the governor was in the steam pipe, which of course, wire-drew the steam.

THE FIRST COMPOUND COTTON-MILL ENGINE

About 1880, the people where I was employed contemplated building a new mill, and having read a great deal about compounding, I was very anxious to have a pair of compound engines put in. Mr. Corliss was much opposed to this, and his excuse was, as I said before, that his engines were doing better than the mill engines of England. Mr. Henthorne was his head draftsman at that time, and being good friends with him we worked the matter together. Finally he consented to build a compound engine; and this was the first compound engine ever built for a cotton mill in this country. The guarantee was 1.67 lb. of coal per horsepower per hour, taking the steam out of the receivers to do the slashing. The engine fulfilled the contract.

Being much interested in the boiler room end, and satisfying myself that nothing more could be done to improve the engine, I turned my attention to developing a system of firing which would make a saving, and from that time to this I have devoted all my time to the boiler room end. I feel that this is the place where the chief engineer of a steam plant should spend his time. I am satisfied that he can make no saving on the engine end or on the turbine end of our steam plants today. All he can do here is to see that they are kept in good condition, properly lubricated, and a high vacuum obtained on the turbines. The saving must be made in the boiler room.

HOW COAL WAS BURNED IN THE EIGHTIES

To show how ignorantly coal was burned in New England in 1883, I was called to take charge of a large steam plant—four woolen mills, and four cotton mills. There were six different boiler rooms in this plant, they were burning anthracite coal and all were small horizontal tubular boilers. Injectors were used to feed them; not a heater nor a pump on the place; they did have pumps, but they abandoned them as they thought it cost too much to keep them in repair. Fires were allowed to burn out every night. No matter what condition the fire was in, all the coal on the grates went out with the ashes and new fires were started in the morning. Pine cord wood at $4 per cord was drawn into the yard every day to start these fires. The ashes were not picked over, and many families in the town got their winter's supply of coal from them; the mill took particular pains to have the ashes hauled down to the dump early in the morning.

All these mills were heated with direct steam, and the overseers were allowed to go into the boiler rooms and turn on the valves when they saw fit. Nearly all the engines were Greene engines, about ten in number. They were given a general overhauling once a year, which consisted of reseating the valves by the use of a bastard file, a coldchisel and a hammer, and then grinding them in with emery and oil; when the job was finished the valves were in worse condition than before. I stopped all this, and had the valves scraped in, and we did not have any overhauling each year.

I want to call your attention particularly to one engine, of which I have a photograph. This engine was built to get over the patents of George H. Corliss. You will see it is a very peculiar engine. My attention was called to it when I arrived at the mills, and was told it was a very good engine because it had a very strong exhaust. I replaced the cylinder on this engine with a Corliss cylinder. They had great trouble in this mill with leaky tubes. Their system was to blow off the boilers every Saturday night and refill them immediately with cold water, keeping the boiler maker and helper busy retubing them. I called the boiler maker's attention to this, asking why he did not stop this system. He said he did not want to take the bread and butter out of his mouth. I told him to go to the office and get his bill. We stopped blowing off the boilers and refilling them while hot, and had no more trouble with leaky tubes.

A 1200-FT. CONDENSING MAIN

We had two mills, one on each side of the river, 1200 ft. apart. Both engines were running noncondensing. No use for the exhaust steam. Having plenty of old pipe in the mill yard, I conceived the idea of connecting the engines and running condensing. The smart ones said it wouldn't work, but they were much disappointed. You can run an engine with the condenser a mile away, providing the piping is tight. All the difference it makes is that it will take a little longer time to get the air out of the pipe before you start. We had a Knowles condenser. After I had accomplished this, I went to Boston to the Blake Pump Co., which then controlled the Knowles pump, and wanted to buy a condenser to do what I had accomplished. They said they would not sell me a condenser. After showing them the cards from the engines, they were very much surprised and changed their opinion.

The first steam plant that I took charge of which I considered uptodate in every way for economy was designed by E. D. Leavitt, Mr. Dean, superintendent. This was in 1887. I will just say this about the engines. They were designed for 1200 hp., the most economical load to run, but, having a great deal of use for exhaust steam, we have loaded these engines from 2000 to 2400. The engines have run continuously since May 1887 with the same crankpin boxes, never having been rebabbitted. The boilers were horizontal tubular, 78 inches in diameter, tubes 18 ft. in length, 3 inches in diameter. Grate surface in boilers 56 sq.ft.

SMOKELESS SYSTEM OF FIRING

This is the time I began to turn my attention to the boiler room end. I feel, and I know, that a system of firing can be established with most any kind of bituminous coal used in New England and have a smokeless chimney, but the boilers must be properly designed. I feel that you can get better results with small units with hand-firing than with any other system. In my observations of other systems, it will be impossible to get any kind of results unless the furnaces are manipulated by skilled help occasionally, to cover up the holes where the furnaces are fed automatically. I think that the horizontal tubular boiler, where there is plenty of room, is the best all-round boiler that can be used for manufacturing purposes.

Take the boilers that were designed by Mr. Leavitt, and started in May 1887. After having been run 18 years under a pressure of 140 lb. and driven away above capacity, the insurance company reduced the pressure to 120, so that we removed these boilers and placed them in other mills where lower pressure was required, and these boilers are running today without having been retubed.

I was once reprimanded about the care of these boilers, because I was using too many manhole gaskets, but I told my superior that manhole gaskets were a great deal cheaper than boiler makers.

AUTOMATIC DRAFT VS. THE TALL CHIMNEY

I feel that you can get a great deal better results with an automatic draft—say, induced draft—than you can with great tall chimney, and it is possible to reduce the stack temperatures very low. I do not believe in tall chimneys. You are limited to the power of the chimney, and you have to carry a high temperature to get draft. For instance, take the stack temperature at the Wood Mills; it has never run above 220 deg., and the boilers are running between 50 and 100 per cent. over rating. With a chimney at that temperature, it would be impossible to get the power of the boilers regulated.

I believe in high furnace temperature, and having the boilers properly designed to absorb most of this heat. The boilers at the Wood Mills are 78 inches in diameter, tubes 20 feet long, 3 inches in diameter, with 2300 ft. of heating surface. With these boilers running 100 per cent. over rating at times, I have never seen the temperature leaving the boilers over 150 deg.

I feel that we cannot pay too much attention to feeding the boilers with water. If you will notice the operations of the steam flow meter attached to your boiler, and watch the fireman as he opens the feed valve carelessly, you will be astonished to see the horsepower drop. I have watched the operations of our boilers, and have had the fireman open the valve carelessly, and the boilers have dropped from 500 hp. to 300 hp. in less than thirty seconds. Just stop to think of the effect of pouring some water into a kettle of boiling water—it is just so with feeding the boiler carelessly.

NEED FOR THE GOLDEN RULE

To obtain the best results in your boiler-room and engine-room force, you must have first a good feeling, and in order to have that good feeling, you must use the men under you as you would want to be used yourself. In my fifty years of experience, no matter in what mills I have been employed, I have never gone outside the mill yard to get help. I have always promoted the men in the mill. This gives the men an incentive to work for, and it makes a great deal better feeling. All of our chief engineers in our mills in Lawrence are young men who have grown up under me.

Another thing I am very careful about—perhaps it is foolish on my part—but I have never yet failed to introduce any who come to visit the plant to the man in charge. In fact, I always have the man show the company around the plant. We all like to be recognized.

Finally, I see a great many young men around me tonight, and I want to leave this parting word. Do the very best you can for yourself and your employer. No matter what discouragement you may meet with, keep on doing your best. If new appliances are put into your hands to use, and you do not feel favorably toward them, banish that thought from your mind and try to make them do better than they were intended to do.

I. E. MOULTROP, of the Edison Illuminating Co. of Boston, said that boiler units are going to increase in size. There was no use in putting in 20,000-, 30,000- and 40,000-kw. turbines and hitching them up to a line of little boilers. The reliability of the boiler is beyond question. At the Delray station in Detroit the reliability of the boilers is even greater than that of the turbines. By using a large boiler you get a greater amount of heating capacity within the same brick setting, and have less firebrick to heat up and cool down. There is less cracking to cause air leaks, and the investment is less. The investment item is the big item; the operating cost is secondary. The operating costs exist only while the plant is running, but the investment costs keep on all the time. The large boiler units take less space and less piping.

NO HAND FIRING FOR LARGE CENTRAL STATIONS

Handfiring is out of the question. The stoker is going to be of the underfeed type. He did not mean to specify any stoker on the market, and would not want to recommend any that is in existence at the present time. The advantages are numerous. One of the principal advantages is that you can force boilers, by which he meant forcing them up beyond anything which has yet been done. One or two stations are running boilers to 250 and 350 per cent. of rating. His company did the same thing at the L Street Station. The Interborough people, in rebuilding the Seventh-fourth Street Station, New York City, contemplate running boilers at 450 per cent. of their rating, and he did not know as that was the limit. This also keeps down the investment and gets away with banking the fires. Few realize how much it costs to carry fires banked.

Another advantage is that you have positive control of your draft. The chimney for a big power plant will cease to be the draft-creating device. Its function will be to take the products of combustion far enough into the air so that the power plant will not be a nuisance to its neighbors. They had had occasions when the load on the station doubled in half an hour. It would be utterly impossible to meet such a condition with any form of boiler-room equipment that depended upon chimney draft.

The boiler room will be equipped with better devices for telling the fireman what is taking place. We give a fireman the most important job in the station, and give him nothing but a cracked pressure gage to tell him how well he is doing it. The steam flow meter is one of the most important devices with which any big power plant can be equipped. We need to know what the draft conditions are, and that they are constant.

Too many automatic devices are bad; the fewer, the better, but what you do have, be sure they are reliable.

FIRE ROOM LABOR

The most important matter is that of fire room labor, and the operation of the fire room is the most important job in a power plant. The economy of the turbine room is in the hands of the constructing engineer. The fire room job has never been congenial. The man who has the intelligence and the ambition to do that sort of work would not tackle that sort of a job. Visitors admire the engine and turbine room, but they stick their heads into the fire room, and duck! Make the fire room just as agreeable a place for the men to work in as possible—neat, clean, well ventilated—and cut out the manual labor. When you make the fire-room job one which the man can run and keep himself as neat and clean as the man in the turbine room, you can get the right kind of men to run it. He did not believe in having the chief engineer sit in the office most of the time looking over charts. Let the clerk do that.

BOILER PRACTICE ONE OF DESIGN

JAMES D. ANDREW, also of the Edison Illuminating Co., of Boston, said that undoubtedly boiler practice is one of design. The simpler the plant can be designed and the more rugged, the better will be the efficiency. In earlier times the belief was prevalent that everything had to be duplicated for safety. As years went on, and the expected failures did not occur, designers were giving up the duplication, with better results. The majority of operations should be made as nearly automatic as possible. The stoking should be automatic, the boiler feed, the combustion control. He did not feel that recorders were of much advantage; they dealt with ancient history. What was needed was indicators which would show what was going on at the time. He spoke of a combustion indicator designed by E. G. Bailey as both ingenious and clever. The back damper of a boiler is a good indicator of what is going out. The steam meter shows the amount of steam delivered. There should be a certain volume of gas delivered by the fire, and the back damper is a good measure of that gas. It is not a difficult matter to put an attachment from the back damper to the front of the boiler and calibrate that telltale so as to show just where the back damper ought to be for each output of the boiler.

After you have made the majority of the operations automatic, see to it that the fireman, instead of sitting down, is busy looking for holes in the fires, etc. Proper weighing apparatus should be provided for keeping track of the amount of coal being burned, and checking it against the electrical output. So far as the feed water is concerned, Capt. Manning is absolutely right. Evaporators for distilling water for the make-up should be provided; such evaporators use high-pressure steam for boiling the makeup water, and then pass the high temperature condensate back to the boiler. Make-up water is seldom over 15 or 20 per cent., and this can be easily provided.

AIR SUPPLY

E. G. BAILEY, of the Fuel Testing Co., said that his hobby was air supply. It takes so much air to economically burn a pound of coal and the pound of coal properly burned will make so much steam; it is a question of relation between the air supply and the steam output. Automatic regulators are worse than useless. Draft recorders are more important than steam recorders. The rate of air supply, with a sensitive damper regulator, varies from 50 to 75 per cent. for a variation of 2 or 3 per cent. in the steam supply. The pressure goes up, and the damper will almost completely close, leaving the fire without a sufficient supply of air, until the pressure is dropped, when it will immediately fly wide open, admitting as much of an excess as there was a deficiency before.

The great problem of today is to supply air to the furnace in exact proportion to the demands for steam.

F. W. DEAN, consulting engineer, of Boston, contributed the following discussion:

It is now well established that the boiler room of a power plant should receive more attention than heretofore. Men of unusual skill and intelligence should be in this department, as here is where lie the greatest opportunities for economy. With recent means of indicating and recording all of the important features of boiler room performance, one can know constantly whether things are going on properly.

Many people do not realize what savings can be made by proper firing unless they have had within their experience cases where it has been shown. I remember one such experience in which the evaporation per pound of combustible from and at 212 deg. was increased from 8.34 lb. to 9.54 lb., and then to 12.84 lb. This was done by putting in a new grate, studying the case in various ways, but chiefly by improving the firing.

The days of reciprocating feed pumps seem to be numbered, and centrifugal steam or motor driven pumps are better in several ways. They give no trouble about packing, can pump hot water, make no pulsations, and render the action of feed water recording apparatus better. On the principle that the most economical steam engine is the simple non-condensing engine of which the exhaust can be utilized, it is best to drive feed pumps and other auxiliary apparatus by steam if the exhaust can be used for heating feed water or otherwise.

Concerning stokers it is my belief that they are indispensable in large public service stations with large overload requirements, but in moderate sized mill plants I do not think that they are advisable unless from conditions, overhead coal storage bins are advisable. In such cases if the plant is not too small a substantial saving in labor can be made because the coal can be delivered into the stoker hoppers through chutes. There is no economy of coal by the use of stokers if hand firing is properly done, for the best hand firing results have not been surpassed by the best stoker results. It should be mentioned, however, that a high grade of intelligence in boiler rooms is not as likely to be obtained, if men have to shovel coal, as would be the case if they directed coal to hoppers through chutes. The limitations of stoker and hand firing economy are of the same character, and they are either too much or too little air. It is easy in hand firing to keep a grate properly covered, but with some kinds of stokers it is not easy. It is here that the underfeed type of stoker has the advantage over other types, in my opinion. I should not forget that some stokers are smokeless and that all are more smokeless than hand firing is likely to be.

LARGE BOILER UNITS AND ARTIFICIAL DRAFT

I am glad to see that the advantages of large boilers in large plants are at last being recognized. I have been advocating them for years, but it is difficult to influence mill men to use them. They cost less per horsepower, take up less room, reduce the cost of brickwork, reduce the size of the boiler house, reduce the number and cost of steam pipes, blow-off pipes, valves, general piping, pipe covering, etc., and finally the number of men required. In addition economy of fuel is promoted, for there are fewer losses from air leaks and radiation. There are no disadvantages, for any boiler is capable of working far above its rating, and therefore if a boiler is laid off the others can do the work.

Furthermore I am glad to see a final recognition of the advantages of artificial draft in large plants, and regarding the chimney as a device for carrying off smoke or invisible gases to a harmless height. A chimney for draft purposes is a relic of past times. Now that it is realized that boilers can be worked at heavy overloads, artificial draft enables this to be done. In central stations this reduces the investment enormously, and yet the peak loads can be carried without difficulty. I have long advocated artificial draft and have installed it several times, one installation being among the largest in New England. This, in connection with large boilers worked hard, has been one of my hobbies.

ONE POWER HOUSE TO A TOWN

JOHN A. STEVENS, consulting engineer of Lowell, Mass., said that to install or not to install is a matter of finance, ground area, cost of buildings, coal in and out, ashes in and out, the cost of labor. How much does it cost over all? The fixed charges are villainous in factory plant work; 8 hours a day for the use of the plant and the fixed charges going on all the time. The tendency of the times is one power house in each city for the generation of power and simple heating plants, one power house, one engineer, and one oil can. In order to determine whether there was anything in feed-water regulators, they ran a 24-hour test, maintaining the water level constant, and another test of the same duration with the water line going up and down 12 inches. The difference in the results was negligible.

With regard to tall chimneys or forced draft, years ago Mr. Rockwood said, "Tall chimneys AND forced draft."

HENRY BARTLETT, of the Boston & Maine R.R., spoke of the automatic stoker as applied to locomotives. It was being applied, not because there appears to be any economy in its use, but because the engines are getting too large to be hand fired.

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Illinois N. A. S. E. State Convention

Hotel Jefferson, Peoria, was the headquarters for the tenth annual convention of the Illinois State Association, which was held on May 20 to 22 inclusive. It was the first of the numerous state conventions to be held this season and was up to the usual standard. Seventy-two engineers were registered, although only thirty-four were delegates, and with thirty firms exhibiting, the attendance must have reached 150. The local committees are to be congratulated on the results of their work. The exhibit hall was the Gold Room of the hotel which offered excellent facilities for the display of engineering specialties, and the meeting room adjoining was convenient and of the proper proportions to suit the attendance. The entertainment was of the variety for which Peoria is noted.

Wednesday was reserved for registration, the forming and renewal of acquaintances and an inspection of what the supply men had to offer. The convention was informally opened Thursday morning. W. G. Zierke, chairman of the arrangement committee, after a few words of welcome, called on Rev. B. G. Carpenter for the invocation. Mayor Woodward officially welcomed the engineers to Peoria and hoped that they would like it well enough to select it as a permanent convention city. He was impressed with the great motive back of the organization and it was his urgent request that they call on him for any services that the city could render.

In his response State President W. E. Hill spoke of the early days when it was the policy of engineers to hoard their knowledge of the engine room. With the formation of an association featured by educational work and an exchange of ideas, the times had greatly changed. The daily work and experiences are now freely discussed and as much help as possible is given one to the other.

John F. McGrath, past president of the national organization, waxed eloquent in an address touching on state license laws, industrial protection and compensation laws and a pension for the aged. The association wanted license laws, not because it is seeking positions for its members, but because it is looking for protection. A clean civil service administration is desired and let the best men take the places. The association is broad minded in every respect. Education is the watchword and every member is willing to stand his chance with any other engineer. Assistance will be given members to get work, but everything will be open and above board. He believed in home rule, but a state license law would not interfere. It was his hope that the Illinois association would have a healthy growth and be as large as any in the country. The members had a happy faculty of sticking together at the national conventions and were respected for it. It is the only way to accomplish results and the same spirit in local matters will make Illinois one of the greatest associations in the country.

Judge Stone impressed on the delegates the necessity for persistence in their efforts to obtain a state license law. It is a good quality and one that is needed to accomplish things worth while. It requires the best efforts of an individual or an organization to be a success in these days. Assistance is the keynote of every organization which has a purpose to carry out. It is needed individually and collectively, for no one can be independent.

In response to a request made by the chairman, Fred W. Raven gave the strongest talk of the morning. It had been nine years since the association met in Peoria and a notable improvement was evident, but he often wondered if all appreciated the fact that they were allowed to belong to an organization that is doing things. It was his opinion that the opportunities of the organization were only half realized by the members. It was a question whether the object of attending was a good time or to help each other. Frequently officers were selected at random. A careful choice was necessary, and if the association was to amount to anything the membership must take a great interest in its work. Education is open today and there is no reason why the members should not be the biggest and brightest engineers in the country. The people of the organization and its possibilities received brief mention. The prospects in Milwaukee were bright for the biggest and best convention ever held. A united effort would insure such a result. Briefly, Mr. Raven reviewed the work of the association for the past year. Ten new locals had been added to the roster, the ladies' auxiliary was growing and the financial conditions were flourishing.

W. F. Raymond, of the local technical school, spoke briefly on the work of the engineer, and the more extended knowledge required in these days. Good books were needed and meeting places for pleasure and mutual instruction.

"Dad" Beckerleg brought back the days in the eighties, the first of the organization. It was due largely to its work that today there were better educated men, better dressed men and better engineers. His closing remarks touched on the pension fund and the life and accident insurance of the association.

A spirited contest between Peoria and Decatur adherents resulted in a choice of the latter for the next convention city. In choosing officers, President W. E. Hill, Secretary-treasurer Gus Anderson and State Deputy Henry Missotto, were re-elected. E. R. Wortman was made vice-president. Installation of officers by "Dad" Beckerleg and short addresses by Charles Cullen, president, and C. H. Fiske, secretary and treasurer of the Central States Exhibitors association, closed the meeting.

The delegates adjourned to the exhibit hall and joined heartily in popular melodies until train time. Some stayed over to the smoker given that evening by the supplymen.

The firms exhibiting at the convention were as follows:

American Steam Gauge & Valve Co.
Anderson Co., V. D.
Armstrong Machine Co.
Carpenter Co., George B.
Chicago Pump Co.
Crandall Packing Co.

Kinsey & Mahler Co.
Liberty Boiler Cleaning Co.
Lunkenheimer Co.
McMaster-Carr Supply Co.
Meyer & Bro. Co., E.
Mueller Co., H.

Delegates and Guests at the Illinois N. A. S. E. State Convention at Peoria, Ill.

President Hill then took the chair and shortly after the convention adjourned. The afternoon was spent sightseeing. The distilleries and the Avery Agricultural Implement Co. were visited, and in the evening a theater party was the feature.

Two sessions were held on Friday and all was business. Reports of officers and committees were presented. The report of the educational committee was enthusiastically received and the license committee was highly commended for its good work. In another year a state license law is expected. To make the constitution consistent and to incorporate the changes that had been made from time to time, a committee on revision had been appointed. The revised sections were read and passed upon, the principal changes relating to the arms of the association, the time of holding and announcing the state convention and representation from the different locals. The smaller associations were given more delegates so that they would not be so greatly outnumbered by the Chicago contingency. One delegate for every 25 members was allowed and no association was to have less than three delegates.

Couch & Heyle
Dearborn Chemical Co.
Garlock Packing Co.
Greene, Tweed & Co.
Hawkeye Compound Co.
Home Rubber Co.
Indian Refining Co.
Jenkins Bros.
Johns-Manville Co., H. W.
Keystone Lubricating Co.

"National Engineer"
National Refining Co.
Peerless Rubber Co.
Peoria Belting & Rubber Co.
Perolin Co. of America
Powell Co., William
"Power"
Thayer & Lynn
White Star Refining Co.

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Storage Dams on the Colorado River

Investigations of dam sites on the Colorado River made by private companies indicate that, in addition to the land now served by canals, more than 1,250,000 acres additional could be brought under irrigation by constructing storage dams on the upper Colorado and its tributaries. About 1,000,000 acres would be served by gravity distribution systems, while about 300,000 acres would require pumping plants to put water in the canals, the lift, however, being nowhere in excess of 80 feet.

The sum of $50,000 which was appropriated in March for the use of the Reclamation Service in investigating storage units and irrigation systems which might be developed on this river is expected to result in a favorable report on a storage capacity at several points totaling between 6,000,000 and 7,000,000 acre-ft. A site on the San Juan River, another at Kremling on Grand River, and a third in northwestern Colorado on Green River, all tributary to the Colorado, have been examined. Of these the last named is by far the largest, and is located in what is known as Ladore Cañon. Here the river banks are such that a dam more than 100 ft. high can be built which will have a water-level length of 500 ft. and yet will be only between 700 and 800 ft. long on the crest. The storage available is placed at 3,000,000 acre-ft.

These several storage units would be independent of the canal systems and would be used only to store water for regulating the stream flow. The probable points of diversion would be at Needles, Parker and Laguna, and would serve lands in the Yuma and Imperial valleys. These dams would make it possible, in the opinion of Louis C. Hill, the Government consulting engineer, who supplied the foregoing information, to irrigate considerable tracts of land in Mexican teritory, although the acreage mentioned is wholly within the United States.

NEW PUBLICATIONS

HOW TO BUILD UP FURNACE EFFICIENCY. By Joseph W. Hays. Published by Joseph W. Hays, Rogers Park, Chicago, 1914. Size 7¼x5 in.; 126 pages. Price, $1

The purpose of this book is to tell in a simple and interesting way why fuel losses prevail in boiler furnace operation; where to look for and measure these losses, and how to maintain economy when it has been obtained. The text is in the nature of conversation by the author with the engineer and the manager. Much of it relates to Mr. Hays' experiences in many plants where he acted in a professional capacity as a combustion engineer.

The little book treats the subject in a manner easily understandable to the average power-plant engineer and such men should, therefore, greatly appreciate its contents.

ENGINEERS' COSTS AND ECONOMICAL WORKSHOP PRODUCTION. By Dempster Smith and Philip C. N. Pickworth. Two hundred and forty-three 5½x8½-in pages; 32 illustrations; 20 tables; numerous specimen forms; cloth bound. Price, 4s. 6d. ($1.12) Emmot & Co., Ltd., Manchester, England.

The interesting and useful contents of this book are not indicated by the title. It is a combined handbook of machine-shop practice and a reference book on the cost of machine building materials. Combined with this are chapters devoted to shop system and organization

The book deals with the costs of material, including pig iron, wrought iron and steel, and copper alloys; tables which include the price of castings in specific districts of England; prices for steel- and copper-finished products, as bars, sheets tubes, castings, and the like. Specifications for materials include the standard tests established by the British Engineering Standards Committee; wage systems, shop organization and management, which are very similar to the treatment given these same subjects in this country; various methods of wage payment and shop systems are explained.

The book also deals with machine-shop practice and the inspection of work and kinds of fits.

The balance is devoted to the bookkeeping end of shop accounting, taking up the methods of applying the expense burden, a discussion of selling expense, a chapter devoted to railway rates, with tables of these rates for British conditions. This is followed by a chapter on the shipping of goods, relating more particularly to the matter of receipts, bills of lading, custom specifications, insurance, etc., the general features of cost keeping, and estimating.

Much interesting and valuable matter is contained in this work; but the specific references are to British conditions and methods.

GEAR CUTTING IN THEORY AND PRACTICE. By Joseph G. Horner; 391 5½x8½-in. pages; 367 illustrations. Indexed. Cloth bound. Price, 7s. 6d. ($1.80). Emmott & Co., Ltd., Manchester, England.

The author in his preface states as his reason for having prepared this book that "Many books have been written on the subject of gears, dealing with the design of teeth and giving some account of the shop practice connected with the formation of the tooth shapes. But none that I know of covers all of the later developments in a reasonably comprehensive manner. Either theory is treated apart from practice, or the work of the shops is dealt with in a too summary fashion." To overcome these difficulties has been his aim; portions of the matter have been previously published as articles in the "Mechanical World."

However, the reviewer fails to be favorably impressed by the result. The first 108 pages, comprising eight chapters, are devoted to a general discussion of tooth proportions and design followed by an analysis of the various methods of cutting. The matter is largely descriptive and contains far too little information to be of final service to the designer. The balance of the book, 257 pages, is devoted to descriptions of commercial gear-cutting machines, with notes on gear-cutting practice. This again, while interesting, seems to be of but little service to anyone except a student.

In view of the excellent works on gear design and gear-cutting practice, already in print, this work hardly seems to add material value to the literature of gear cutting.

BOOKS RECEIVED

HEAT. By E. M. Shealy. McGraw-Hill Book Co., New York. Cloth; 262 pages, 6x9¼ in.; 110 illustrations. Price, $2.

McANDREW'S FLOATING SCHOOL. By Captain C. A. McAllister. International Marine Engineering, New York. Cloth; 256 pages, including 21 pages of tables for marine engineers; 6x8¾ in.; illustrated. Price, $2.

ENGINEERING AFFAIRS

Cincinnati Joint Meeting—The joint meeting on June 4 of the Engineers' Club, of Cincinnati and the Cincinnati Section of the American Society of Mechanical Engineers will be addressed by a representative of the National Tube Co. on the subject, "The Manufacture of Steel Tubes." The address will be illustrated with motion pictures. The meeting will be held at eight o'clock p.m., in the auditorium, McMicken Hall, University of Cincinnati. This will be "ladies night," and the last meeting of the club until fall.

Summer Courses at University of Wisconsin—Announcement is made of the fourteenth annual six weeks' summer school of the College of Engineering of the University of Wisconsin, which opens on June 22. Courses of instruction and laboratory practice are offered in electrical, hydraulic, steam and gas engineering, mechanical drawing, applied mechanics, testing of materials, machine design, shopwork and surveying, in addition to which subjects may be taken in the College of Letters and Science.

The Annual Dinner of the New York Chapter of the American Society of Heating and Ventilating Engineers was held on the evening of May 18 at Reisenweber's Beef Steak Garret, 57th St. and Eighth Ave., about 125 members and guests attending. Informal addresses were delivered by Walter S. Timmons, the recently elected president of the chapter, and also by several other members, congratulating the chapter on the work done during the past year and bespeaking higher public appreciation of the profession of heating and ventilating engineering.

OBITUARY

GEORGE MILLARD

George Millard, of Burlington, Ia., secretary of the Citizens Water Co. and for many years connected with the Murray Iron Works Co., died May 4 at the age of forty-five years. Mr. Millard left a widow.

M. CARELS

The death of Mr. Carels was announced at Ghent on April 27. Mr. Carels was one of the founders of the firm of Carels Fréres, and the uncle of Messrs. Charles, Georges and Gaston Carels, who are now conducting the business. The deceased was born in Ghent in February, 1839. He was director of the Hospices Civils of his native town, chairman of the board of directors of the Hauts-Fourneaux et Laminoirs de la Sambre, and Officer of the Order of Leopold and of the Legion of Honor.

Classified Advertising

Positions Wanted, 3 cents a word, minimum charge 50 cents an insertion, payable in advance.

Positions Open, Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work), For Sale, 5 cents a word, minimum charge, $1.00 an insertion.

Miscellaneous (Educational Books) 10 cents a word, minimum charge $1.50 an insertion.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion.

POSITIONS OPEN

WANTED FOR PANAMA CANAL, experienced erectors for the erection of lock machinery, salary, $140 month; free transportation from New York or New Orleans, must be American citizens (final papers), under 45 years, in sound physical condition. Write Panama Canal Office, Washington, D. C.

POSITIONS WANTED

TECHNICAL GRADUATE in mechanical engineering desires position as apprentice with concern manufacturing power-plant apparatus; location New York City or vicinity. P. W. 236, Power.

CHIEF ENGINEER-MASTER MECHANIC, large experience, good mechanic and executive, water-works, refrigeration, office building and factory experience; young, married and sober. P. W. 234, Power.

STEAM AND ELECTRICAL ENGINEER is open for position, experienced, technical education; first-class license; civil service; reference. West or Middle West preferred. Address "Engineer," Convent of Holy Names, Oswego, Ore.

MECHANICAL ENGINEER, unmarried, 26, Stevens graduate, good experience in power plant, experimental and executive work, possesses initiative, unusual mathematical ability, desires change; will go anywhere. P. W. 230, Power.

SUPERINTENDENT of power of large group of power plants, desires to correspond with employers requiring the services of a high-grade power-plant engineer; thoroughly experienced in all branches, and can deliver results; only a strictly high-grade position, and salary commensurate with same is solicited. P. W. 214, Power.

SUPERINTENDENT of stations or chief engineer; 10 years' experience central-power station, erecting and operating steam turbines and engines, high-tension transmission lines; first-class Ohio license; at present employed as superintendent of power stations; best of references. P. W. 235, Power.

ENGINEER, technical graduate, 10 years' experience with large engines, Curtis, Parson and Rateau turbines, up to date on electrical and refrigerating machinery, formerly chief engineer in large hotel, would like to correspond with a firm where exceptional ability and low-power production is appreciated; can furnish first-class references from past and present employer. P. W. 228, Power.

WANTED

WANTED—100 to 250 H. S. fuel-oil engine, De La Vergne F. H. type preferred; must be in good condition and cheap for cash; state age, make, send number and lowest cash price, also when same may be seen. W. 231, Power.

AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

MR. ENGINEER—If you are tired of the daily rut of your job and are ambitious to make a way for yourself in the selling end of the engineering line, we have something unusual to offer you; become a sales engineer and earn three to six times as much as your present salary; you can do it without any risk whatsoever, but you must possess certain qualifications; write us and we will tell you if you are eligible. We manufacture boiler appliances of the highest merit and standing, selling as high as $400 per boiler, and yielding in commissions as high as $100 per boiler; one sale may mean more than your week's salary; write us. W. 229, Power, Chicago.

MISCELLANEOUS

PATENTS. C. L. Parker, patent attorney, 904 G St., Washington, D. C. Inventor's handbook sent upon request.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

CARR VENTILATED FURNACE ARCH gives 100 to 400 per cent. longer service than ordinary types; for nominal fee I will furnish plans with license to use, or will take pay in percentage of saving made. Elmer E. Carr, 411 Hartford Bldg., Chicago.

FOR SALE

ATLAS ENGINE—One 11-in. by 16-in., automatic cutoff, in fair condition, may be seen in operation. F. S. 233, Power.

BUCKEYE ENGINE—One 13-in. by 21-in., automatic cutoff, in good condition; may be seen in operation. F. S. 232, Power.

BOILERS—Two 50-hp., 54-in. by 12-ft. return-tubular boilers, in excellent condition; will sell for $200 each f.o.b. cars Lockport, N. Y. F. S. 218, Power.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

CORLISS ENGINE—16x36 Hewes & Phillips Corliss, with wheel 12'x19", perfect condition, overhauled, $550. Duzets & Son, Hudson Terminal, New York.

ALTERNATOR—100-kw. G. E. type "ATB," rev. fld. 3 ph. 60 cyc. 240 volt alternator with exciter and switchboard, $550. Also 17x24 Erie City 4-valve engine, $750. Duzets & Son, Hudson Terminal, New York.

OIL ENGINES—32-hp. De La Vergne oil engine, perfect condition (cost $1900), $750; also 30-hp. Meitz & Weiss oil engine (cost $1500), $550. Duzets & Son, Hudson Terminal, New York.

TURBINE GENERATING SET—300-kw. Westinghouse Parsons three-phase, 60-cycle, 220- or 440-volt turbine outfit, with condenser; practically new. George Sachsenmaier & Co., 143 North Third St., Philadelphia, Penn.

COCHRANE HEATER—One No. 3, rebuilt and in excellent condition, $95; one American steel plate blower, three-quarter housing, bottom horizontal discharge, 24-in. inlet, first-class shape, $65. The Arbuckle-Ryan Co., 224-34 Cherry St., Toledo, Ohio.

BOILERS at Wilmington, N. C.—Battery of three 125-hp. horizontal tubular; insured 125 lb.; stack, 66 in. diameter, 90 ft. high, and breeching; manufactured by the E. Keeler Co.; cost, $3500 f.o.b. cars; will sell at bargain. McKenzie Mfg. Co., 765 North Ave., Plainfield, New Jersey.

FOR SALE AT BARGAIN, after July 1, one Armington & Sims cross-compound engine, 150 hp., 11½ and 18 by 15; write us for price or make us an offer. Memphis Electric Light, Heat & Power Co., Memphis, Mo.

PATENTS, PATTERNS, etc., for the simplest device for prevention of smoke on the market; this device is in successful operation; will sell outright, or on royalty basis; this device can be sold for less money and at a good profit than any other device on the market. F. S. 217, Power.

INDICATORS AND GOVERNORS FOR SALE—Steam-engine indicators, standard make, at $25 each; 4-in. Class "A" Pickering governors, at $20 each; 4½-in. Class "A" Pickering governors, at $25 each. All of the above material is in fine condition; full information upon request. Address Lyons Atlas Co., Indianapolis, Ind.

CONTRACTS TO BE LET

Bids received until June 10, 1914.

Heating Apparatus, etc.

Supervising Architect's Office, University of Illinois, Urbana, Illinois.—Sealed proposals for furnishing and installing all materials as per drawings and specifications for heating apparatus and auxiliaries for Armory, will be received at this office until 2 P.M., June 10, 1914. Information on application.

JAMES M. WHITE,
Supervising Architect.

POWER

Vol. 39 NEW YORK, JUNE 9, 1914 No. 23

"Sol" Engineer's Advice

MY son, consider the small steam leaks, how they grow. They cease not, neither do they sleep. They hiss and spue out in derision at thy fondest dream of great things to be accomplished, verily, even while thou art boastfully declaring thy great worth to thy employer—which would be even greater if thou only hadst a chance.

Consider, also, the invisible leaks, perchance, through the brickwork of the furnace. Surely thou knowest they also are wasteful. Say not, "the Old Man will not supply material and help." Help thou thyself to some good yellow clay if nothing better be at hand; are not bricks also made of the same?

Consider again thy raiment, which may become thin; even more so in that part which cometh in contact with thine easy chair, lest it afford thee scant protection should thine employer rise up in just indignation at thy slothful ways and apply his boot vigorously.

If thou knowest not all that which is taught in the books, thou doest well if thou doest thoroughly all those things which thou dost know.

Surely, thy employer can see. If not, it is clear then why thou art still on his payroll! My son, get thou busy.

Steam-Electric Power Plant at Hauto, Penn.--I

By Warren O. Rogers

SYNOPSIS—The plant is located in the anthracite mining district to utilize coal dust and other unmarketable low-grade fuel in the boiler furnaces. At present there are eight 1000-hp. water-tube boilers and three 12,500-kw., maximum rating, horizontal turbines served by Leblanc condensers hung from the base of the turbines to take care of contraction and expansion. Condensing water is taken from the Hauto reservoir and, after passing through the condensers, is discharged into the reservoir 2800 ft. from the intake.

*

A boiler and turbine plant which eventually will have at least 32,000 boiler horsepower in 32 units and 100,000-kw. turbine capacity, exclusive of 25,000 kw. reserve, has recently been placed in operation at Hauto, Penn., by the Lehigh Navigation Electric Co. So far, however, eight 1000-hp. boilers are in place, although eight more of equal capacity may be added in the near future.

Throughout the anthracite coal regions of Pennsylvania there are vast deposits of culm, washery screenings and the like, and, although much of this fuel is of fair calorific value it has but little, if any, market value. This refuse contains fine sizes of anthracite, such as buckwheat No. 3 and smaller, which can be burned in boiler furnaces properly designed and handled. It is proposed to burn this refuse near its place of production, thereby saving the transportation charges and transmit the electric power generated to near-by and distant points. One great electrical plant will supply power to surrounding industries in place of transporting coal to be consumed in many more or less uneconomical steam plants.

Building

To obtain an adequate supply of condensing water, the plant, a general view of which is shown in Fig. 1, is located on Nesquehoning Creek. A siding is provided from the Nesquehoning R.R., which connects with the Lehigh & New England and the Central R.R. of New Jersey. Construction was begun about 19 months ago, and the engineering and supervision work was done by the firm of L. B. Stillwell, consulting engineers, New York City.

The power house was built on a hillside. It is practically five stories high from the condenser basement to the coal-discharging room above the coal bunkers, the tops of which are level with the boiler-room roof.

The building is of heavy structural steel and brick, the face work being laid in texture brick. The sills, lintels, copings and base of the structure are of reinforced concrete, finished smooth. An unusual amount of window area has been provided in rolled-steel sashes with wire-glass panes.

The smoke uptakes are above the boiler-house roof, and the shape of each, Fig. 1, is due to the provision made for putting economizers on the roof at some future date, if desirable.

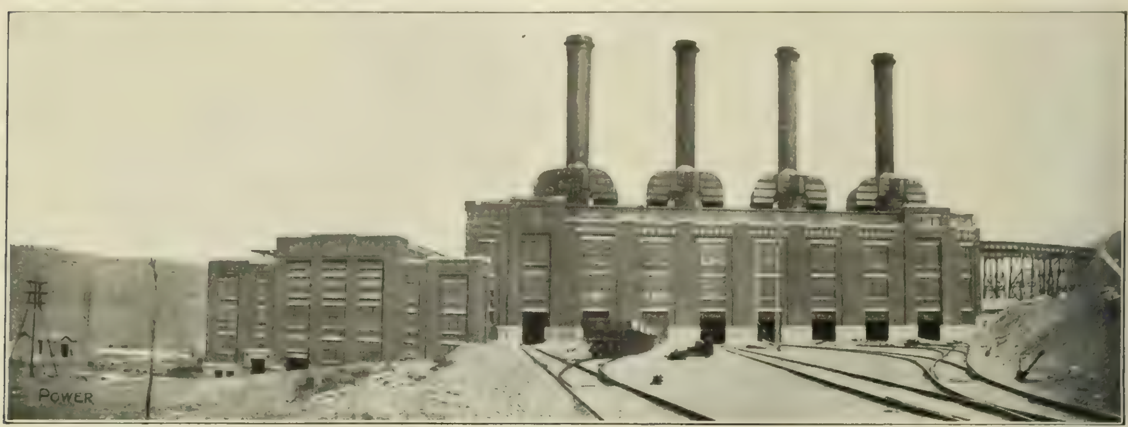


Fig. 1. General View of the Hauto Power Plant, Hauto, Penn., Containing at Present Eight 1000-Hp. Water-Tube Boilers and Three 12,000-Kw. Steam Turbines

The overall dimensions of the present plant are 416x195 ft. The building has two main sections in the form of a tee. The boiler room is 68 ft. wide and 285 ft. long, and is built at right angles to the turbine room, which is 131 ft. wide and 195 ft. long.

Turbo-Generators

There are now three 10-stage, turbo-generators, each with a maximum rating of 12,500 kw. The turbine blading is a modification of the Rateau form.

The generators, Fig. 2, are three-phase, 25-cycle machines, operated at 11,000 volts. The rotors have fan blades to draw air for cooling through the machine and discharge it at the top of the casing. This cooling air is taken from outside through air ducts into the conduit room, thence through cloth screens to an air chamber under the turbine casing. At 10,000 kw. the temperature of the generators does not exceed 40 deg. C. in a 24-hr. run.

In each chamber are three 208-kv.-a. reactance coils which are cooled by the air going to the generator. These coils consist of a continuous cable wound on a concrete core separated by wooden spacing stops with asbestos-pad insulators between the cable and the wooden stops. A reactance coil is connected to each of the three leads of each alternator. Each reactance produces a 4 per cent. drop with 525 amp. flowing per terminal of each machine at 11,000 kw. and 100 per cent. power factor.

The main generating units are placed crosswise of the turbine room, and the steam pipe to each above the strainer extends in a long-radius bend to the header chamber. Each turbine has a 14x14-in. trip and throttle valve. The 14-in. elbow between the throttle valve and the strainer has a blind flange connection to which a U-bend pipe is bolted and acts as a support to the main steam pipe. Between the legs of the U-bend is a gage board carrying the several gages, mercury column and signal panel for stopping and starting the unit.

The operating platform of the turbo-unit is about two feet above the concrete flooring. Between the first and second unit and between the third turbine and the end wall is an opening above the pump compartment in the basement.

Steel spiral stairways lead to the balcony and the basement from the operating floor.

Midway of the turbine-room floor at the generator end of the main units are three 300-kw., 250-volt exciter sets, two of which are direct driven by six-stage turbines, at 1800 r.p.m.; the other is driven by a 450-hp. induction motor at 750 r.p.m.

Each main turbine exhausts into a No. 24 Leblanc condenser, Fig. 3, the largest of its kind yet built. The condenser is bolted to the underside of the turbine and hangs free, with about two inches between the bottom of the condenser and the basement floor. This gives the condenser free movement to expand and contract.

The double-impeller, centrifugal circulating-water pump is housed in the exhaust casing of the condenser; the small dry-air pump is on the outside, as shown. These pumps are mounted on the same shaft and driven by a single-stage, 445-hp. turbine, operating at 700 r.p.m. The shaft connection between the condenser and the turbine is long enough to allow for whatever movement of the condenser takes place as a consequence of the changes of temperature.

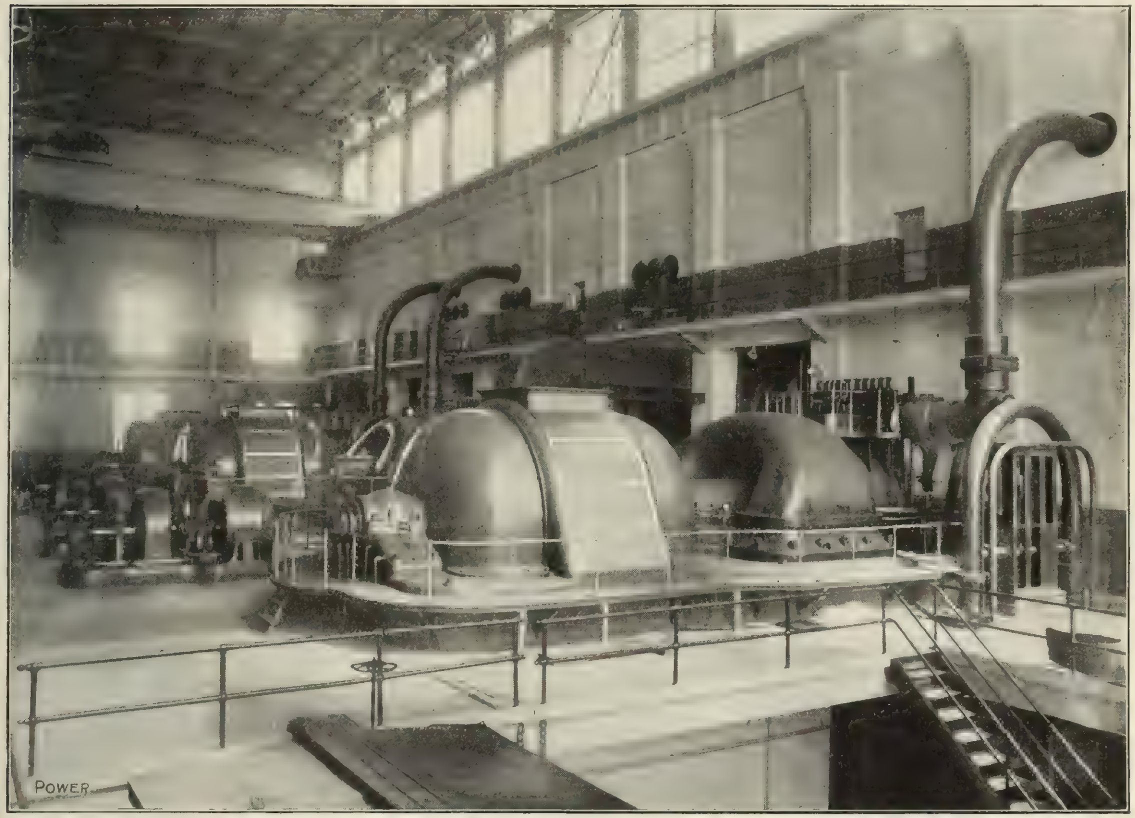


Fig. 2. Three 12,500-Kw. Turbine Units; Maximum Rating, 12,500 Kw. Under Normal Operating Conditions the Steam Consumption Is 12.3 Lb.

Priming water, supplied by a set of reciprocating pumps, flows to the air pump until sufficient vacuum has been formed to lift water from the intake tunnel by atmospheric pressure. With a 29.1-in. barometer the condenser will maintain a vacuum of 28.1 in. when condensing 150,000 lb. of steam per hour.

Condensing Water Supply

Enough condensing water, not only for the present but when the total output of the station will be at least 100,000 kw., was necessary. It was, therefore, decided to construct a dam for the enlargement of the existing

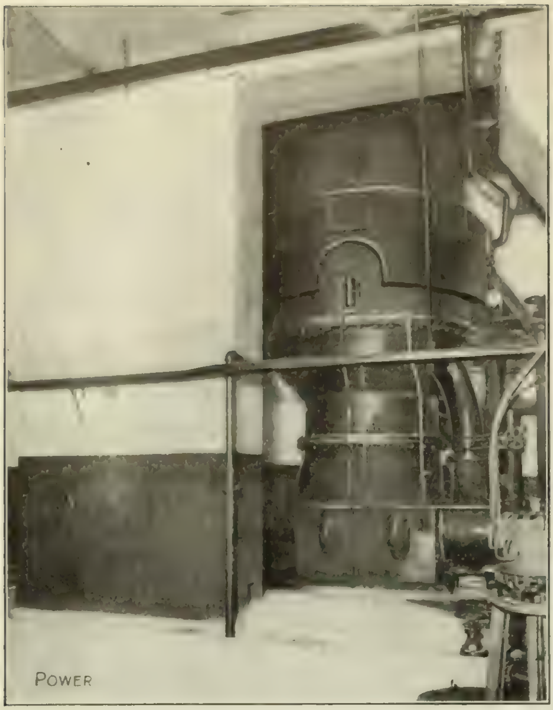


Fig. 3. Leblanc Condenser Hung from the Turbine Casing, Thus Eliminating the Expansion Joint Frequently Placed between the Casing and Condenser

Hauto reservoir to serve the joint purpose of a cooling pond for the condensing water from the power plant and the storage of an increased water supply for the collieries and other customers of the Panther Valley Water Co.

The new dam was built across the Nesquehoning Creek below the old one. It is made of earth mainly excavated from the power-house site, and is 1800 ft. long, 30 ft. high and 15 ft. wide on the crest; it slopes two to one on both sides. The face on the upstream side is protected by concrete slabs, with the joints between them filled with bitumen. This facing is carried down over the front, forming a concrete cutoff wall that protects the earth part of the dam from contact with the water. At the far end of the dam is a spillway, Fig. 4. It is built as an open flume, with a flat bottom and is designed to carry the maximum recorded flood. It must take care of the water from the watershed above the dam, which has an area of about 10 square miles and furnishes about 4,000,000,000 gal. of water yearly. The water is free from acid, sulphur, etc., as no mine discharge empties into it above the plant.

Condensing water is taken from the lower end of this reservoir through a 13.5-ft. square concrete intake tunnel, which connects with a second tunnel running parallel with the plant and having manholes at convenient intervals. This lateral tunnel is 8 ft. wide and 9 ft. high. Openings 6 ft. high communicate with the intake wells from which 112-ft. lengths of 30-in. cast-iron pipe are carried to the three condensers.

If the water in the reservoir becomes so low during the summer months that the head is insufficient in the intake tunnel, such loss of head will be compensated for by two engine-driven centrifugal pumps housed in the pump house at the edge of the reservoir near the dam and intake tunnel. Each pump has a capacity of 70,000 gal. of water per minute and is driven by a 23x17-in. engine. The 30-in. pipes leading to the condensers have hydraulically operated gate valves, which can be partly closed when the turbines are running with a light load. They can be kept at any desired degree of opening, however, by setting a controlling nut on the extended tail-rod mechanism of the hydraulic cylinder of each valve.

The discharge from the condenser is through about 30 ft. of 30-in. pipe which is carried to the main discharge

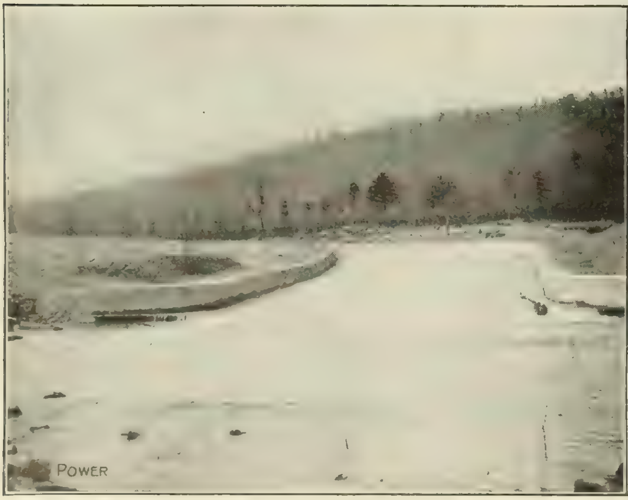


Fig. 4. Spillway at the End of the Reservoir Dam, Designed to Take Care of Maximum Flood Stages. The Dam Is Shown at the Left

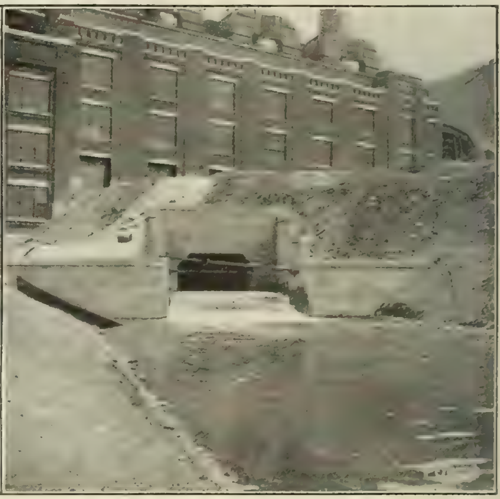


Fig. 5. Discharge Portal Where the Condensing Water Flows to the Discharge Canal

tunnel extending the length of the turbine room at the back of the condensers in the basement. It is of concrete and is 12 ft. wide, and 15 ft. deep in the center. The discharge outlet, Fig. 5, has a weir with an adjustable crest, which maintains a definite water level on the discharge side of the condensers. This serves to maintain a height of water back of the crest sufficient to keep the end of the 30-in. discharge pipes from the condensers submerged.

A discharge canal conveys the water from the portal of the discharge tunnel to a point at the upper end of the reservoir. The canal is at present 2800 ft. long, but when the plant is enlarged and more cooling surface is required in the reservoir, the discharge outlet will be carried further up the valley to a point about 6500 ft. above the intake tunnel. This will give the water time to cool before it is again used in the condensers.

PRINCIPAL EQUIPMENT OF THE HAUTO STEAM-ELECTRIC POWER PLANT OF THE LEHIGH NAVIGATION ELECTRIC CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Turbines	G.E., horizontal	12,500 kw.	Main units	225 lb. steam, 100° F. superheat, 1500 r.p.m.	General Electric Co.
3	Generators	Alt. current	12,500 kw.	Main units	1500 r.p.m., 3-phase, 25 cycles	General Electric Co.
3	Generators	Direct current	300 kw.	Exciter units	1800 r.p.m., 250 volts, one 750 r.p.m.	General Electric Co.
2	Turbines	G.E., horizontal	300 kw.	Driving exciter units	1800 r.p.m., 225 lb. steam	General Electric Co.
1	Motor	Induction	450 hp.	Driving exciter unit	750 r.p.m., 250 volt	General Electric Co.
3	Condensers	Leblanc	No. 24	Main turbines	28-29 in. vacuum	Westinghouse Mch. Co.
3	Turbines	Single stage	445 hp.	Condenser pumps	700 r.p.m., 225 lb. steam, 100 deg. superheat	Westinghouse Mch. Co.
8	Boilers	B.&W. low W	1000 hp.	Steam generators	225 lb. steam, 100 deg. superheat	Babcock & Wilcox
24	Grates	Hand fired, dumping	8x12 ft	Boiler furnaces	Hand firing	Acme Furnace Equipment Co.
8	Grates	Automatic traveling	7x12 ft.	Boiler furnaces	Automatic stoking	Coxe Travelling Grate Co.
3	Fans	Sirocco	6 ft. No. 12.	Forced draft	360 r.p.m., motor driven	American Blower Co.
3	Motors	Induction	450 hp.	Driving draft fans	360 r.p.m., 2300 volts, 3 phase, 25 cycles	General Electric Co.
3	Turbines	Single stage	125 hp.	Driving boiler-feed pumps	2900 r.p.m., 225 lb. steam	Terry Steam Turbine Co.
3	Pumps	Centrifugal	4-in.	Boiler feed	2900 r.p.m., turbine driven	Henry R. Worthington
5	Pumps	Reciprocating	8x12x14x12 in.	Feedwater and priming	Low head	Henry R. Worthington
2	Injectors	Compound		Auxiliary boiler feed	Emergency	Eynon-Evans Mfg. Co.
16	Meters	Venturi	3 in.	On boilers	Continuous	Builders Iron Foundry
2	Meters	Venturi	6 in.	On boiler main feed line	Continuous	Builders Iron Foundry
2	Pumps	Centrifugal	48 in.	Emergency condensing water	In use during low water	Alberger Pump & Condenser Co.
2	Engines	Reciprocating	23x17-in.	Driving emergency pumps	In use during low water	McIntosh & Seymour Engine Co.
2	Motors	Induction	10 hp.	Driving sump pump	Intermittent service	Westinghouse Elec. & Mfg. Co.
9	Transformers	Oil cooled	3350 kv.a.	Step-up 11,000 to 110,000 volts	25 cycles, 3-phase, 11,000-110,000 volts	General Electric Co.
9	Switches	Oil	110,000 volt	High-tension circuits		General Electric Co.
1	Crane	Traveling	110 ton	Turbine room	Motor, operated	Whiting Foundry Equipment Co.
1	Pump	Vertical, duplex	7x5x12 in.	Oil system	Intermittent	Dean Bros. Steam Pump Co.

The next installment of this description will deal with the boilers, the forced-draft system, and the method employed in handling the coal and ash.

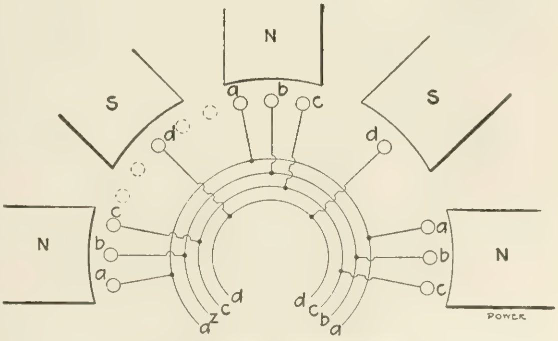
⁂

Equalizing-Ring Requirements

Multiple-connected generator armatures have as many independent current paths from machine terminal to machine terminal as there are field poles in the machine. The distribution of the total current in the several independent armature paths is affected by ununiform distribution of the air gap around the armature, so that part of the armature conductors run in a denser field than another; ununiform resistances of contacts between the brushes of different holders and the commutator, so that the resistance of one independent path may be higher than that of another; and ununiform spacing of the several sets of brush-holders, so that the e.m.f. across one set of holders may be greater than that across another set of holders. To minimize the effects of slight ununiformities, armature conductors that should be at the same potential at the same time are sometimes connected by means of conductors called "equalizers."

The general plan of equalizing by means of such rings is indicated in the accompanying sketch in which part of an eight-pole generator is shown. Here it will be noted that conductors occupying a given position relative to a pole piece of certain polarity are connected to a bus-ring to which are also connected all other conductors similarly situated with regard to a polepiece of the same polarity. On modern generators all equipotential armature conductors may be found to be equalized; on others, they may be equalized only at certain intervals; on still others, there may be no equalizers. In any event, the full possibilities of equalizing connections cannot be realized unless the number of poles and the taps and the total number of armature conductors involved are so related that the taps may be exactly equispaced.

In a case in mind, a multipolar machine that had no equalizers sparked because of unequal distribution of current among brush-holders; the operator installed equalizing rings, but this did not seem to give any relief. Investigation revealed that the relation between the number of poles and the conductors was such that equal spacing of the equalizer taps was impracticable. Equalization was finally improved by adjustments of the air gap, the brush tensions and the brush spacings.



EQUALIZING CONNECTIONS

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Skill as an Asset—As a man remains in the employ of a firm so his particular skill on his job increases. This skill does not represent an item of cost to the firm, but it does represent an asset; his skill and knowledge are direct money value to the shop where he is employed, and his departure diminishes the capital of the firm by that amount. This value can never be expressed directly in dollars and cents. If it could be, many a manager would think twice before laying off men.—"American Machinist."

Draft for Smokeless Combustion*

By Osborn Monnett†

SYNOPSIS—Breeching area, stack area and height and the proper draft over the fire to burn smokelessly Western bituminous coals or shavings.

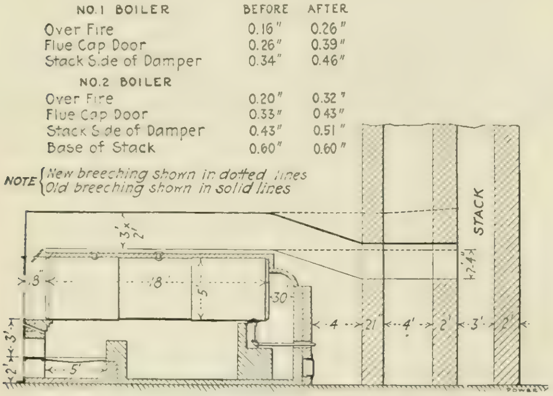
⁂

Breeching Area

With water-tube boilers it is good practice to allow a ratio of breeching area to grate surface of 1 to 4½ or 5. In large central stations a ratio of 1 to 3½ has been used where the boilers are run habitually at 100 per cent. over rating, but this is a special study not considered in the present article. The ratio of 1 to 4½ or 5 for rated capacities is based on a gas travel of approximately 18 ft. per sec. with a breeching temperature of 500 deg. F. This will give a maximum gas travel of about 28 ft. per sec. for a 50 per cent. overload and will provide sufficient area to take care of ordinary fluctuations in load.

Theoretically the loss in a horizontal run of breeching will be about 0.1 in. of water per 100 ft. of length. In practice, this can well be doubled, due to accumulations in the breeching, loss by radiation, leaks, etc., remembering that the designer should figure the breeching to meet the most adverse conditions likely to be encountered.

Breechings should be well lagged to prevent radiation, and the covering should be placed on the outside, so that it will be in plain sight and need for repair can be easily seen. A lining on the inside is difficult to repair and deterioration might readily escape detection.



NO. 1 BOILER	BEFORE	AFTER
Over Fire	0.16″	0.26″
Flue Cap Door	0.26″	0.39″
Stack Side of Damper	0.34″	0.46″
NO. 2 BOILER		
Over Fire	0.20″	0.32″
Flue Cap Door	0.33″	0.43″
Stack Side of Damper	0.43″	0.51″
Base of Stack	0.60″	0.60″

NOTE {New breeching shown in dotted lines
Old breeching shown in solid lines
STACK
3′x2′
8″
18″
5′
30″
2′4″
4
21″
4′
2′
3′
2′
3′
2′
5′

Fig. 1. Showing Detrimental Effect of Drop in Breeching

The loss in a right-angle bend can be taken as 0.05 in. of water. Under no circumstances should the breeching take a drop below the horizontal. Fig. 1 illustrates the detrimental effect of such a drop and gives the draft readings before and after making the change which affected the available draft over the fire approximately 100 per cent. Sacrifice everything to a straight, uninterrupted run of breeching. Do not allow conduits, ventilating ducts, etc., to take precedence in a matter which vitally affects the plant during its entire life. Loss of draft through a breeching should be figured from the boiler farthest from the stack. Each additional boiler connected to the breeching will cause a drop, due to the friction or interference of the gases as they enter the breeching, or to leakage through the damper when the boiler is out of service. This additional draft loss may be taken at 0.05 in. of water per boiler connected to the breeching. Any bends in the breeching should be eased off in long sweeps and the stack connection should be at an angle of 45 deg.

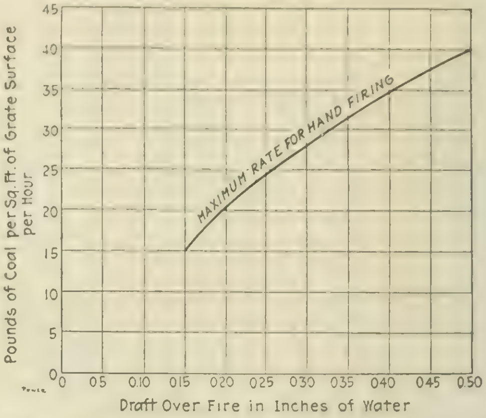


Fig. 2. Draft Intensity for Smokeless Combustion

Draft vs. Rate of Combustion

In practice, it has been found that the draft over the fire required to burn Western bituminous coals in well designed smokeless furnaces is approximately 0.01 in. of water per pound of coal. When burning 15 lb. of coal per square foot of grate surface per hour this ratio holds exactly. As the combustion increases, the draft is a little greater in proportion. This is shown in Fig. 2. For instance, at 21 lb. of coal the draft is 0.205 in.; at 30 lb. it is 0.33 in., and at 40 lb. the draft is 0.5 in. It must be understood that the curve is for the ordinary run of bituminous coal when considered from the standpoint of smoke suppression. Free burning coal of this character will burn after a fashion with less draft; that is, the fixed carbon will be consumed, but most of the volatile matter will pass off unconsumed and will make a great deal of smoke.

The draft curve shown has been obtained by averaging thousands of draft readings in plants burning Western bituminous coals smokelessly. While the drafts given may seem excessive to some engineers, yet experience has shown that they are necessary to get the best results.

Burning Shavings

Shavings will burn satisfactorily with half the draft required for coal; that is, 0.005 in. of draft per pound of dry shavings per square foot of grate surface per hour, provided they are fed through a chute by a blower. This holds good up to 0.6 in. of draft over the fire, which is sufficient for 120 lb. of dry shavings per square foot of grate per hour. Wet, fine shavings and sawdust, hand fired, or a mixture of shavings and coal require approximately the same draft over the fire as coal alone. In designing a new plant it is, therefore, advisable to provide for the maximum draft to take care of emergencies.

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†Smoke Inspector, city of Chicago.

Stack Dimensions

In analyzing the draft conditions in several hundred plants it was found that a stack area of one-fifth of the connected grate surface gave the best results. This ratio provides a gas velocity in the stack of about 30 ft. per sec. at maximum loads. A ratio of 1 to 6 has been employed with success in many installations, and with exceptionally high stacks, such as are found in skyscrapers, 1 to 7 is allowable. For the ordinary commercial plant, a ratio of 1 to 5 is much better and will give sufficient capacity for peak loads and smokeless operation.

The following formula given in "Stirling" for draft intensity has worked out well in practice:

$$D = 0.52\ H \times P\left(\frac{1}{T} - \frac{1}{T_1}\right)$$

where

D = Draft in inches of water;
H = Height of top of stack above grate bars in feet;
P = Atmospheric pressure in pounds per square inch;
T = Atmospheric temperature, absolute;
T_1 = Absolute temperature of stack gases.

At ordinary altitudes, variations in the atmospheric pressure may be disregarded, but where the plant is at a high elevation it is best to use in the formula the corresponding air pressure.

For the usual sea-level air pressure of 14.7 lb. and a temperature of 60 deg. F., the formula may be reduced to $D = KH$ where

$$K = 0.52 \times 14.7\left(\frac{1}{T} - \frac{1}{T_1}\right)$$

This necessitates the computation of values for constant K for various flue-gas temperatures such as are given in Table 1.

TABLE 1. VALUES OF CONSTANT K FOR VARIOUS FLUE-GAS TEMPERATURES

Temperature of Stack Gases Deg. F.	K
750	0.0084
700	0.0081
650	0.0078
600	0.0075
550	0.0071
500	0.0067
450	0.0063
400	0.0058
350	0.0053

Then to find the draft in inches of water it is only necessary to multiply the height of the stack in feet by the constant corresponding to the temperature of the stack gases. Conversely, to find the height in feet of a stack to produce a certain draft, divide the draft in inches of water by the constant corresponding to the flue-gas temperature.

A stack temperature of 500 deg. is seldom exceeded and 475 deg. is a good average figure, owing to the various losses which occur between the boiler uptake and the stack.

Table 2 may also be used to determine the size of stack for horizontal tubular boilers. The dimensions given, however, apply only when the boilers are connected to the chimney by a straight run of breeching which has fully as much area as the stack and in which long narrow sections are not used and sudden changes of section are avoided.

TABLE 2. SIZES OF CHIMNEY FOR HORIZONTAL RETURN-TUBULAR BOILERS

Size of Boiler	Number of Boilers on Stack				
	One	Two	Three	Four	
48″x14′	21½″x90′	30″x100′	37″x110′	42½″x120′	34-3½″ tubes
54 x16	24½ x95	34½x105	42½x115	49 x125	34-4″ tubes
60 x16	28½ x100	40 x110	49 x120	57 x130	46-4″ tubes
66 x18	31 x110	43½x120	53½x130	61½ x140	54-4″ tubes
72 x18	35 x120	49½x130	60½x140	70 x150	70-4″ tubes
78 x20	39½x130	56 x140	68 x150	78½ x160	84-4″ tubes

⁂ ⁂

Economical Auxiliaries in a Refrigerating Plant

By K. M. Gilbert

SYNOPSIS—Reduction in fuel consumption resulted from the use of economical auxiliaries. A jet condenser and cooling tower were replaced by an atmospheric steam condenser; belt-driven pumps were used instead of duplex steam pumps. Power for auxiliaries is obtained from the main engine. Steam trap for feeding boiler.

⁂

The chief engineer of a small refrigerating plant "made good" by giving much time and study to improvement in the efficiency of the auxiliaries. When the engineer took charge of the plant, the machinery consisted of:

One 100-hp. return-tubular boiler; 130 lb. pressure.

One 12 and 24 by 21-in. tandem compound Corliss engine, directly connected to two single-acting 14x21-in. ammonia compressors.

One 8 and 12 by 12-in. vacuum pump with jet condenser.

One 6 and 7 by 6-in. duplex pump for cooling water to ammonia condensers.

One 4½ and 2¾ by 4-in. feed pump.

One 6 and 6 by 6-in. air compressor.

These pumps were all necessary for the operation of the plant. There were also one or two other small pumps used occasionally.

The amount of water available was so small that it was necessary to use two cooling towers; one for the steam condenser and the other for the ammonia condenser water. The main engine was run condensing, the vacuum being obtained by means of the jet condenser and pump which discharged the condensing water to the top of the 30-ft. cooling tower.

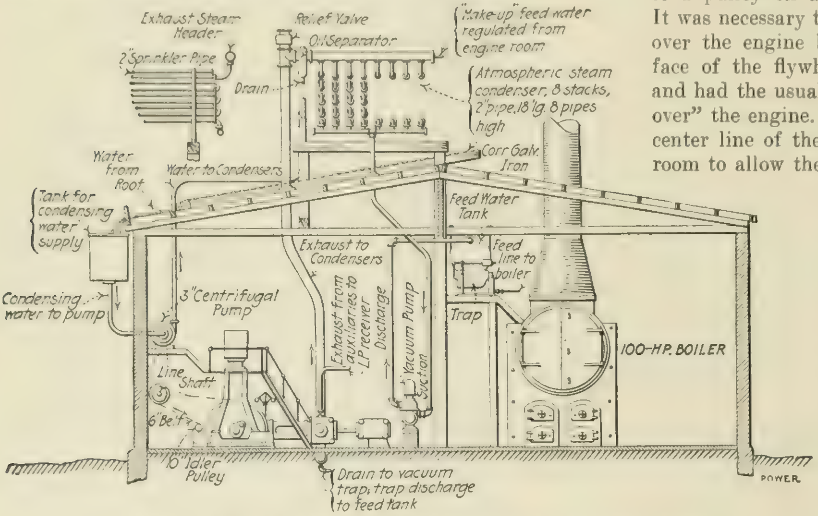
The exhaust from all but the condenser pumps was discharged through the feed-water heater into the atmosphere. The amount of heat in the exhaust was more than could be used in the feed water, so the surplus steam passed off to the atmosphere and considerable heat was wasted.

The horsepower and steam consumption per hour of the main engine and auxiliaries were as follows:

Main engine	100 hp. at 18 lb. steam per hp.-hr.	=	1800
Jet condensing pump	6 hp. at 30 lb. steam per hp.-hr.	=	180
Feed pump	1½ hp. at 100 lb. steam per hp.-hr.	=	150
Ammonia condenser pump	6 hp. at 90 lb. steam per hp.-hr.	=	540
Air compressor	6 hp. at 40 lb. steam per hp.-hr.	=	240
	Total steam consumption per hr.	=	3210

Coal burned per hr. = about 400 lb.

The plant was operated with this machinery for one season, during which time the chief carefully studied all the faults of the plant and came to the conclusion that the high fuel consumption was due entirely to the inefficient auxiliaries. The management had complete confidence in the engineer, so that when fall came he was able to start in and make all of the changes which he had studied out to give the best economy. The sketch shows the arrangement of the machinery at the beginning of the second year.



LAYOUT OF ICE PLANT, SHOWING LOCATION OF AUXILIARIES

The jet condenser was replaced by an atmospheric steam condenser made from an ammonia condenser. This type of steam condenser gives pure water for boiler feed, takes less horsepower for operation and does not require the use of a cooling tower. The connections from the condenser to the engine and to the vacuum pump are shown. The water for condensing the steam was pumped by a 3½-in. centrifugal pump, which discharged the water into a 2-in. pipe placed over each section of the condenser. On the top of these pipes were drilled ⅜-in. holes 4 in. apart, through which the water flowed over the condenser pipes and thence to the roof. A suitable gutter and lead pipe conducted the water into a tank, as shown, to which was attached the suction of the centrifugal pump. The condenser was drained by a 6 and 7 by 10-in. single-cylinder pump, which discharged into a 42-in. by 8-ft. horizontal feed tank placed above the boiler.

Small boiler-feed pumps consume a large amount of steam for the work done and, in addition, require oiling, packing and considerable attention. I believe a steam trap is the cheapest method of feeding boilers. The temperature of the water and any irregularity in the feed has no effect upon the proper working of the trap. By reference to the sketch, the relative location of the feed tank, the trap and the boiler can be seen. The volume of the steam used by the trap for each discharge is equal to the volume of the trap, and when the trap has discharged its contents into the boiler, the steam contained in the trap is discharged into the feed tank.

The 6 and 7 by 6-in. duplex steam pump for pumping water to the ammonia condensers required 540 lb. of steam per hour. This was a large amount of steam for the work done and just how to reduce this item of expense caused the engineer considerable worry. Finally, he decided to install a 7x8-in. triplex pump. The power for driving this pump, and also that for the centrifugal pump, for water to the steam condensers, was derived from the main engine. By reference to the sketch, it will be seen that a 6-in. belt was run over the flywheel to a pulley on a line shaft back of the engine. It was necessary to use an idler to guide the pulley over the engine bedplate onto the flywheel. The face of the flywheel was flat, about 14 in. wide and had the usual 2-in. square holes for "pinching over" the engine. The belt ran on one side of the center line of the rim so that there was sufficient room to allow the pinching bar to enter the holes.

The idler pulley did not give the least bit of trouble and, furthermore, it was useful in guiding the belt onto the wheel, for, by simply changing the position of the ball-and-socket bearings for the idler shaft (by use of the setscrews), the belt could be made to run on any part of the flywheel rim. The pulley on the line shaft was fitted with a friction clutch, enabling the engineers to stop the line shaft without shutting down the main engine. In addition to the reduction in steam consumption, the triplex pump required less oil and less packing and repairs than were necessary to operate the duplex pump, with its multiplicity of rods and valve-gear parts.

The exhaust steam from the 6 and 6 by 6-in. air compressor and the 6 and 7 by 10-in. vacuum pump was more than could be used in the feed-water tank. In order that no steam should be wasted, the exhaust from the air compressor was discharged into the low-pressure receiver to do work in the low-pressure cylinder, and was exhausted into the main steam condenser. A 1-in. pipe was run from the receiver to the feed-water tank to supply steam to the feed water when the exhaust steam from the vacuum pump was insufficient to heat the water to about 210 deg. F.

After making these changes, as illustrated, the steam consumption and horsepower of the various units were as follows:

			Lb.
Main engine	110 hp at 18 lb. steam per hp.-hr.	=	1980
Vacuum pump	2½ hp. at 90 lb. steam per hp.-hr.	=	225
Air compressor	6 hp. at 45 lb. steam per hp.-hr.	=	270
	Total steam consumption per hr.	=	2475

Coal burned per hr. = about 300 lb.

By comparing these figures with the foregoing, both of which were obtained by actual test, it is seen that the new system of auxiliaries reduced the coal consumption 100 lb. per hour, or 2400 lb. per day, which at $3.20 per ton makes a daily saving of about $3.50. The plant was operated at full load 300 days in the year, so that the fuel saving amounted to more than $1000. The cost of making the changes was $1200, so that the interest on the investment was more than 80 per cent.

The arrangement of the machinery, as shown in the sketch and described above, was, to the writer's knowledge, successfully used for three years. During this time, no serious trouble was experienced. The steam condensers gave a vacuum of 22 to 24 in. in the hottest weather, and a supply of pure feed water for the boilers. The makeup feed water amounted to about 150 lb. per hour. As this was the only source by which impurities could enter the feed water, it is evident that no trouble whatever was had with boiler scale. The condensing water, in passing over the condenser tubes, was heated and some of it evaporated. The loss of condensing water, by evaporation, was just about equal to the amount of steam condensed, which, in hot weather, varied from 2000 to 2500 lb. per hour. Attention should be called to the fact that with this type of steam condenser it does not take any more water to run an engine condensing than it does noncondensing, with the steam escaping to the atmosphere. The amount of water saved by condensing the steam is, as noted, about equal to the amount of makeup water supplied to the condensing water to replace that loss by evaporation, but more of the heat in the exhaust steam is being returned to the boiler.

The Fulton Oil Engine

Notable as the first Diesel engine of American design to be put out in sizes as small as 50 hp., is that recently built by the Fulton Manufacturing Co., Erie, Penn., and shown in Fig. 1. The engine is designed primarily for marine service and operates on the four-stroke cycle. In the 50-hp. size three cylinders are employed, four for 70 hp. and six for 100 hp., all 8x9 in.

The arrangement is such that any cylinder head may be removed without disturbing the camshaft which is mounted on ball bearings and is driven from the crankshaft by an intermediate vertical shaft with helical worm gears. The cam levers are of cast steel, with hardened tool-steel rollers and pins with screw adjustment for clearance at the tappet ends. The suction and exhaust valves, in the cylinder head, are of tungsten steel and interchangeable.

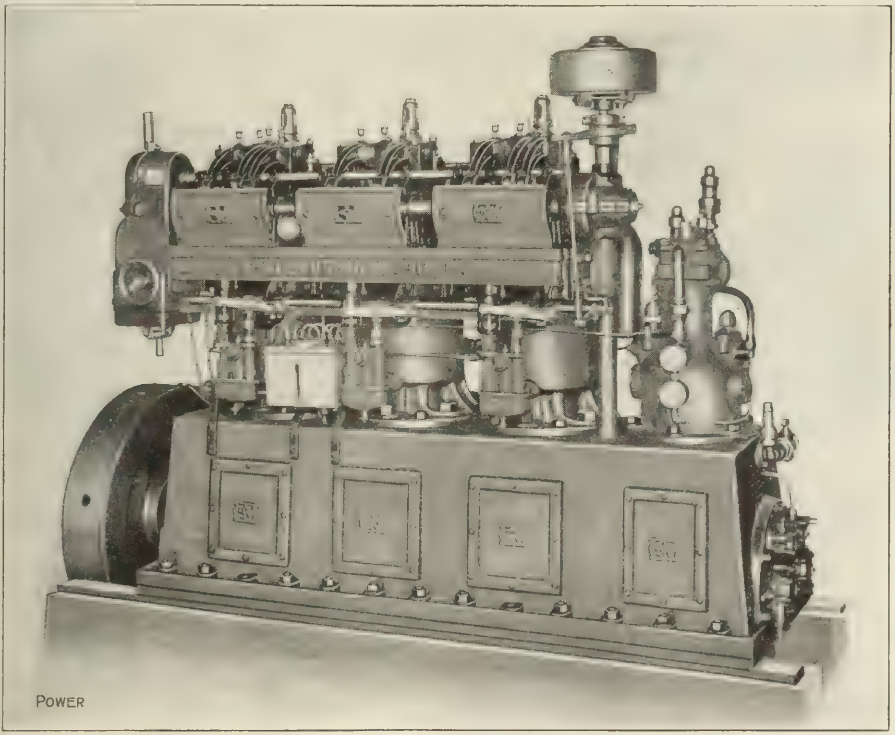


Fig. 1. 50-Hp. Three-Cylinder Fulton Engine

Air Compressor

The air compressor is on the center line and at one end of the engine, being driven directly from the main shaft. It is of the two-stage type, as shown in Fig. 2. Free air is drawn into the lower cylinder through the strainer and duplex suction and delivery valve, and is compressed to about 120 lb. It is then delivered to the intercooler (the coil at the right), thence to the high-pressure or upper cylinder. From here it passes to a second cooler and finally to the receivers for fuel injection. Slightly more air is delivered than is necessary for fuel injection and this surplus is carried to two larger receivers, of 2458 cu.in. each, for starting. The pressure for fuel injection is regulated by hand according to the load, full load requiring about 975 lb., half load about 800 lb. and 10 per cent. overload, 1000 lb. Both the suction and the delivery valves in the high-pressure head are supplied with renewable seats and can be inspected without disturbing any of the pipe connections.

The fuel-injection valve and atomizer are in the cylinder head. The body is of bronze and the needle valve of nickel steel. A heavy compression spring closes the valve and it is forced open by a cam lever. Referring to Fig. 3, it will be seen that the oil is delivered on one side, passing down to the lower part of the atomizer. Air is admitted on the opposite side, but is led to the upper part of the atomizer behind the oil. Atomizing is effected by the perforated disks, and when the needle valve is raised the oil is blown into the compression space of the cylinder, in finely divided particles where it is ignited by the heat of compression. The grooves at the lower end impart a whirling motion to the injection air, which tends to clean out all the fuel, besides having a tendency to complete the breaking-up process begun by the perforated disks.

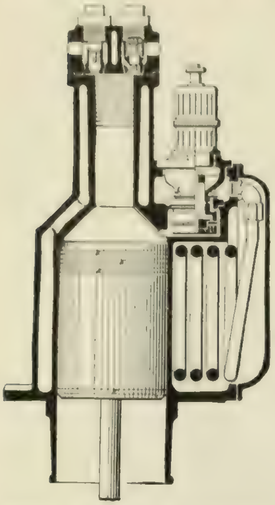


FIG. 2. SECTION THROUGH COMPRESSOR

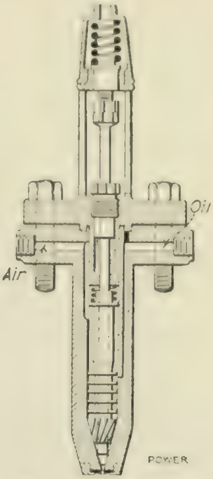


FIG. 3. FUEL VALVE AND ATOMIZER

FUEL PUMP

On the three-cylinder engine shown in Fig. 1 there are three separate fuel pumps, one for each cylinder. In the later design, however (Figs. 4 and 5), one fuel-pump unit serves three cylinders. Referring to Fig. 5, it will be seen that this unit has three displacement plungers and three separate sets of valves, one for each cylinder. On the suction stroke of the plunger, oil enters the pump chamber through the suction valve *A*. On the delivery or downward stroke this fuel is bypassed through the control valve *B* (shown in the right-hand view). When this control valve is closed the charge is forced through the delivery valve *C* to the fuel atomizer. The amount of fuel fed to the cylinder, and hence the speed of the engine, depends upon the action of the control valve *B*; that is, while the stroke of the displacement plunger is constant, the amount of oil bypassed through valve *B* determines the amount supplied to the cylinder. The timing of this valve is accomplished by means of a sliding cam which rotates at a speed determined by the engine, but the position at which it becomes effective is subject to the movement of the governor arm.

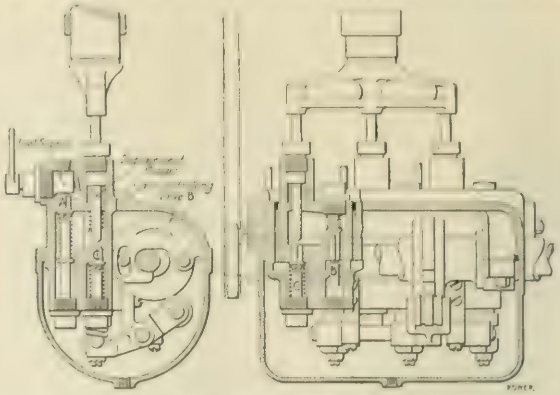


FIG. 5. FUEL PUMP

To render the pump inoperative, as is required when wishing to cut out a cylinder, means are provided for holding open the suction valve. The fuel pumps may be operated by hand without disconnecting from the drive. An inclosed fly-ball type of governor is employed.

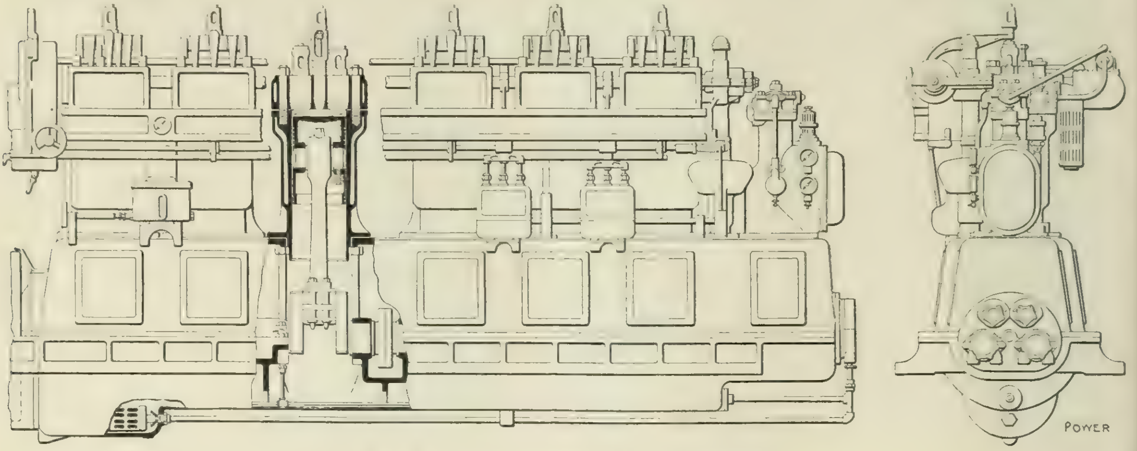


FIG. 4. SIX-CYLINDER, 100-HP. ENGINE

LUBRICATION AND CONTROL

Forced lubrication is supplied to all of the crankshaft bearings and wristpins. The crankshaft is drilled through its entire length and a small, self-priming rotary pump circulates the oil from the engine bed to all the bearings inside the crank case and up through the hollow connecting-rod to the wristpin. An overflow valve regulates the pressure, which is normally held at 15 lb. In addition, there are attached to each working cylinder two feeds and one to the air compressor, from a force-feed oiler.

A handle and handwheel at the front of the engine, supplemented by interlocking push buttons, provide the operator with the necessary means for easy control. The handle has three positions: "barring," "air start" and "running," the buttons being so interlocked with the handle that starting air and fuel cannot be supplied to a given cylinder at the same time.

The cylinders upon which the air start is provided must be bypassed before the starting handle can be placed in the "air start" position. With the handle in the barring position all the fuel is bypassed so that should the engine be turned over a number of times the cylinders cannot become flooded with oil. The handwheel serves to put more or less load on the governor, thereby increasing or decreasing the engine speed.

⁂

Turbine-Valve Lubrication

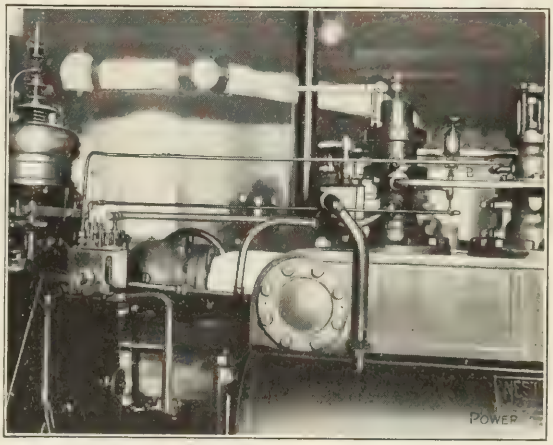
By Paul B. Prutzman

The primary and secondary valves of a Westinghouse turbine need little lubrication, and this is usually supplied by means external to the turbine itself. I have found that the force-feed cylinder-oil pump, which is commonly used on the valves of a reciprocating engine can be used satisfactorily and at a saving in cost of oil, which, if figured by the year, will more than offset the cost of the pump and all attachments.

The idea of coupling one of these pumps to a turbine came to the writer after having taken charge of a central station in the eastern part of Pennsylvania consisting entirely of Westinghouse turbines. Naturally the condensed steam was used for boiler feed and it was necessary to keep it as free from oil as possible. In this respect the force-feed pump caused no trouble. Heretofore the valves were lubricated by means of the small brass cup shown at *A*, which holds about a quarter of a pint. As soon as the valve *B* was opened, admitting pressure, no matter how little, all of the oil was immediately forced into the turbine valve, thereby wasting a large percentage of it without mentioning the damage to the boilers from oil in the condensate. The cup was not refilled for four to six hours, or until the engineer thought the valve might need it.

Considerable trouble from sticking valves led me to try a new method. A force-feed pump was obtained on 60 days' trial and was given a thorough test under the most trying conditions. To mount the pump a suitable bracket was made and bolted to the bearing cap nearest the governor gear case. It extended out on the side so as to bring the pump in line with the oil pump supplying the turbine bearings. It was necessary to bring it above the bearing cap about 18 in., so that the connecting-rod, when in motion, would clear all parts of the turbine. The crosshead pin in the turbine oil pump was drilled for a 3/8-in. capscrew, and this screw acted as the main driving pin for the cylinder oil pump. The operating lever was made at first 6 in. long, but as this made the feed too fast, it was increased to 12 in., which proved about right. The operating lever had a 120-deg. throw and the turbine oil-pump plunger an 8-in. stroke, with 80 strokes per min., so that the feed could be brought down considerably. The connecting-rod being attached to the operating lever with an adjustable thumb-screw, it was an easy matter to increase the feed while running, and adjustment was also possible by means of the small thumb-screw on the pump deck controlling the feed. The former method is preferable on account of the size of the drop remaining the same.

One of the principal advantages arising from this method of lubrication is the regularity with which the valve will receive its supply of oil. I have found that a drop about the size of a match head every 3 min. is sufficient to keep the valve in perfect condition, regardless of the changes in load. As an indication of the saving in oil it may be stated that heretofore a quart of oil usually lasted about 24 to 30 hr., while with the pump in use it lasts for about 110 hr. of continuous running.



Oil Piping to Turbine Valves

It is necessary to have two feeds on the pump so as to lubricate both the primary and secondary valves of the turbine, but as the pumps are usually made with two or more feeds, this did not prove a disadvantage. As the secondary valve only comes into play at full load or on overload, it can be shut off by means of the small screw on the feed plunger until it is needed, and then by a half turn of this screw it can be easily brought into action.

The photograph shows the sight-feed pump, and the 1/8-in. piping to the two valves. There is a check valve in each line close to the valve. As the valve uses up about all the oil that is fed to it, the condensed exhaust steam contains very little oil.

Temperatures of High-Speed Generators

By J. M. Long

Temperature is an important item which requires close attention in the operation of high-speed generators, particularly of the steam-turbine-driven and large high-speed waterwheel-driven types. This is necessary for the reason that, in the design of such apparatus, the windage developed by the high speed of the rotor is depended upon largely for the proper ventilation of the generator.

The ordinary method of reading temperature by placing thermometers in different parts of a generator seems insufficient, except perhaps to ascertain the approximate temperature of the iron. With the machine in operation, thermometers placed against parts of the winding that are accessible register temperatures of air in motion adjacent to the winding rather than the internal temperature of the armature coils.

Furthermore, temperature readings thus obtained with the machine standing still are too low, because the rate of cooling from a high temperature is so rapid after the load has been taken off that by the time the rotor has been brought to rest, it is impossible to determine what the temperature was under full-load conditions.

The average internal temperature of an armature winding may be found by measuring the resistance of the armature, cold and hot, and applying a formula based on the temperature coefficient of copper and thermometer readings of the cold armature. But this method is insufficient for the same reason as given with reference to the rapid rate of cooling after the load is taken off. It is impossible to obtain hot resistance measurements under full-load conditions.

Another method, which seems best adapted to measuring the temperature under full-load conditions, is by the employment of temperature-measuring coils, noninductively wound. These may be placed between coils, or between the coils and the iron, in the slots of an armature where the highest temperatures obtain. It is by measuring the resistance of these coils that accurate temperatures may be determined in the armature of a high-speed generator under full-load conditions.

The accompanying data, derived from the temperature test of a 12,000-kw., high-speed generator, is illustrative of the three different methods employed in the same heat run. While the summary of results indicates that the different methods in themselves may be accurate and check within a few degrees, it will be noted, by reference to the column headed, "Rate of Cooling," that during the one hour elapsed between the time the generator was fully loaded and the time all tests were completed after the generator had been brought to a standstill, the armature had cooled off approximately 35 deg. C.

TEMPERATURES OBTAINED BY THERMOMETER, RESISTANCE AND TEMPERATURE-COIL METHODS

Armature—Hot

Armature Phases	Current Amp	Drop Millivolts	Resistance Ohms	Thermometers No	Thermometers Deg. C.	Coils No	Coils Deg C
A - B	3.56	83.0	0.02331	1	65	1	71.5
A - B	7.64	184.0	0.02408	2	63	2	73.0
A - B	7.00	169.8	0.02426	3	65	3	62.8
A - B	3.92	144.2	0.02436	4	67	4	73.5
				3	65	5	62.0
A - C	5.00	120.0	0.02400	6	63	6	63.9
A - C	6.00	145.2	0.02420	7	67	7	62.5
A - C	7.70	185.8	0.02413	8	67	8	63.0
				9	65		
B - C	5.00	120.0	0.02400	10	67		
B - C	6.02	145.5	0.02417	11	66		
B - C	7.70	185.7	0.02412				
		Averages	0.02406		65.5		68.5

Resistance Temperature per Formula

$$t_2 = (238 + t_1)\frac{Rt_2}{Rt_1} - 238$$

t_1 = temperature cold
t_2 = temperature hot
Rt_1 = resistance at t_1
Rt_2 = resistance at t_2

Based on Cold Thermometer Readings	Based on Cold Bulb Readings
64	64.8

Armature—Cold

Armature Phases	Current Amp.	Drop Millivolts	Resistance Ohms	Thermometers No.	Thermometers Deg. C.	Coils No	Coils Deg. C.	Rate of Cooling Condition	Rate of Cooling Time	Rate of Cooling No. 2 Bulb
A - B	3.16	68.5	0.02168	1	*31	1	38	Loaded	9.20	101
A - B	4.96	108.0	0.02177	2	*30	2	36	Load off	9.23	
A - B	7.14	159.0	0.02227	3	*30 } 30	3	36.5	Off line	9.25*	97
				4	*30	4	39		9.30	92
A - C	3.14	69.0	0.02196	5	36	5	37		9.35	90
A - C	4.98	108.5	0.02178	6	38	6	37	Stopped	9.36	
A - C	7.06	153.0	0.02167	7		7	38	Field off	9.37	
				8	38	8	37		9.40	87
B - C	3.16	69.0	0.02183	9	37				9.45	84
B - C	4.98	108.1	0.02171	10	38				9.50	81
B - C	6.80	147.0	0.02162	11	39				9.55	79
									10.00	77
		Averages	0.02181		36.6		37.3		10.05	76
									10.10	75
									10.15	71
									10.20	66

Summary

Resistance temperature based on cold thermometer readings	64.0
Resistance temperature based on cold bulb readings	64.8
Temperature per hot thermometer readings	65.5
Temperature per hot generator bulb readings	68.5

*Thermometers 1, 2, 3, and 4 in same location near air inlet with manhole cover off. Cold readings figured as of one thermometer.

This substantiates the contention that it is practically impossible to measure accurately the internal temperature of an armature operating under full-load conditions by the thermometer and resistance methods.

Eleven thermometers were distributed in different parts of the armature so as to measure the average temperature of the coils, except that thermometers 1, 2, 3 and 4 were in the same location. The eight temperature coils, also distributed in different parts of the armature, were of a standard make, were calibrated at a known temperature before being put into the machine, and were connected with a reliable instrument which registered the degrees Centigrade.

The results of temperature measurements in electrical apparatus are apt to be misleading when derived under any other condition than that of full load; and the only way of determining temperatures under such conditions seems to be with temperature coils so arranged that changes in their resistance, as affected by heat, may be measured and reduced to degrees of temperature.

Burning Fuel Oil under Boilers

By W. G. Greenlees

SYNOPSIS—Some practical experience with the burning of fuel oil, and the various methods employed. The use of targets is condemned. A burner which will spread the flame at the front is recommended and a fire floor level from front to back.

⁂

When fuel oil was first discovered in Texas in large quantities, this entire section of the country was at once given the advantages of cheap fuel. However, instead of applying this cheap fuel in such a way as to obtain a high efficiency in its use, in many plants, especially small ones, the simplest possible method of oil burning was adopted. Some of these methods were crude in the extreme and inefficient. It was not uncommon to see in a laundry, well drilling rig or other small plant, a locomotive-type boiler with the fire- and ashpit doors entirely removed, the burner placed in the center of one or the other and aimed with geometrical precision at the center of the tube sheet. The burner itself, consisted of a piece of pipe flattened at one end to spread the blaze and the other end terminated in a tee, the oil line being connected to one side of the tee and the steam to the other.

In defense of such a primitive outfit, it may be said that like many other things which have come and gone, it served its purpose. It was easily applied and generated the required amount of steam at a much lower cost than would have been possible with any other fuel.

Incidentally, it may be said that right here is where oil burning got its "black eye," for people burning oil in this way or some other way equally reckless are the only ones that ever found oil burning "hard on the boiler." Whenever a man aims an oil burner at his tube sheet or boiler shell, he may as well make a standing contract with the boiler maker. Trouble is sure to come if the boiler is being fired up to its capacity.

Early Indifferent Design

Of course, no pretension is made that any such methods of oil burning are or were prevalent in the large stations. Yet it is true that little enough was done to insure economy in the furnace until the almost general adoption of oil as a fuel brought its price up until coal and lignite entered the field as lively competitors. Men who had been "cranks" on complete combustion when burning coal, stuck a burner or two under their boilers, put a torch to it, stepped outdoors to look at the stack to see that it was not smoking and then turned it over to the fireman. They were confident that it would work, but they did not care how much oil it burned, for oil was cheap.

The writer knows of one plant where a 250-hp. B. & W. boiler is fired with two burners in the ashpit aimed at a brick target. There is no way provided for regulating the draft, and while there is doubtless an excess of air admitted to the furnace, anyone familiar with oil burning could tell by the sound of the fire that the air is not properly mixed with the fuel.

Oil is no longer cheap, and in practically all plants of any importance the utmost care is being taken to secure the best results. Fourteen pounds of water evaporated per pound of oil burned is a result frequently obtained. Generally speaking, the principles of combustion apply to burning oil as well as anything else. The application of the burners, arrangement and dimensions of the furnace, etc., depend entirely upon the type of boiler. But, as intimated at the outset, great care in all cases must be exercised not to localize the intense heat on the surface of the boiler, regardless of the type. A sufficient amount of air properly admixed with the fuel while at the ignition temperature is all that is necessary to obtain complete combustion. To do this is not always an easy matter, and a method that will give excellent results with one type of boiler will fail utterly with another.

In one large plant there are five B. & W. boilers with which a saving of 11 per cent. was made by changing to the back-shot type of burner. A manufacturer of traction engines having the ordinary locomotive type of boiler, uses the back-shot burner, aiming the burner at a firebrick wall erected just in front of the fire-door, and claims that three barrels of oil do the work that it required four to do when the oil was introduced at the fire-door, and discharged toward the tube sheet. The writer equipped a return-tubular boiler with a back-shot furnace, assuring the owner that it would be a money saver, but the results were expensive and humiliating.

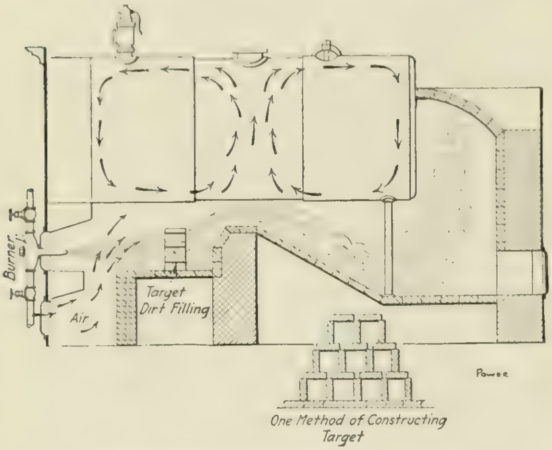
A Poor Arrangement

There is one method of applying an oil burner to a return-tubular boiler, which at one time was popular, but cannot be too strongly condemned, both because of its wastefulness and because it is productive of serious priming and expensive boiler repairs. The usual bridge-wall is constructed, the grate bars are omitted and the ashpit bricked up solid or filled in to the grate-bar level. Just inside the fire-doors, an opening the entire width of the furnace and 5 or 6 in. across allows air to pass upward from the ashpit doors. The burner is introduced through a hole between the fire-doors, and is usually directed against a target placed about two-thirds of the way between the boiler front and the bridge-wall. The accompanying sketch will make this clear. The errors and dangers of such a method are obvious. In the first place, it is impossible to obtain economical combustion. Cold air is admitted the entire width of the furnace and the first thing it strikes is the shell of the boiler, converting it into a condensing surface. A portion of this air will be drawn in and mingle with the blast of oil and steam issuing from the nozzle of the burner, but conditions do not at all favor a proper admixture of air and fuel. To obtain a sufficient amount of air to produce complete combustion, a large excess must be supplied, which, leaving the furnace at a high temperature, reduces the economy.

The second feature of this furnace to attract attention is the target. The object of the target is to spread the blast and cause the flame to fill the furnace, at the same time providing an incandescent surface to assist the combustion. Anyone who has ever used a target in this way knows how impossible it is to secure a uniform spreading of the flame in the furnace. Ever so much care may be exercised in erecting the target, and it may prove successful for a short time after the fire is lighted, but the intense heat soon reduces the firebrick to the consistency of putty and they begin to gravitate in the direction of the least resistance. Inside of an hour or two the target looks like a piece of molasses candy on an August day, and the blast from the burner is directed perhaps against the sidewalls, which is bad enough, or against the shell of the boiler, which is much worse.

In the majority of cases where a target is used under a return-tubular boiler. It will be found that the blast of the burner impinges on a small area of the boiler shell at a point almost directly under the dome or steam pipe. The effect is twofold. First, it is dangerous and injurious to the boiler, and, second, it interferes materially with the steaming qualities.

No matter how clean the internal surfaces of a boiler may be, if the full force of an oil burner is directed against a small area of the shell it is certain that the heat will be imparted to the spot faster than the water will carry it away. I have been inside of boilers where I could tell exactly where the flame struck the shell by the discoloration of the plate. Besides the effect of such localized heat is to set up stresses in the plate that are apt to result in leakage at the girth seams, cracks and possibly an explosion.



Effect of Target in Oil Burning

On the other hand, it is evident that the water in the boiler will ascend from the hottest portion of the shell. Consequently if the hottest spot is directly under the dome, the water will rise most rapidly at this point instead of over the grates as it is supposed to do. There will be a double circulation. Rising in the middle it will divide, one current flowing toward the rear and the other toward the front. Each will turn downward and join again at the point of highest temperature, as indicated in the illustration. As this point is kept intensely hot, the ascent of the water and steam bubbles will be rapid, and bursting through the surface of the water they will be certain to carry some water into the dome or steam pipe. It is almost impossible for a boiler fired in this way to furnish dry steam. Engines taking steam from a boiler fired in this way have primed badly even on light load, but the priming disappeared when the method of firing was changed.

A target under a return-tubular boiler is always dangerous, but with the ordinary type of burner, if a target is not used, the first few square feet of heating surface at the front of the boiler will be of little use, for there will be little fire at the front. The heat will be farther back, and probably double-circulation will result.

There are two ways of successfully meeting these difficulties. One is by the use of a type of burner which spreads the fire at the front of the furnace without the use of a target. The other is by the use of a dutch oven; and in either case the air must be admitted below the fire and introduced in fine streams so as to use as little as will suffice to give complete combustion. There are a number of burners on the market, which give the spreading effect. In the plant of which I have charge, spreading burners are used. There are no bridge-wall nor grate bars. Two-inch scrap pipe is placed across the furnace, 8 or 10 in. below the usual grate-bar level, and supported on brickwork at the sides and middle. These are covered loosely with firebrick so spaced as to admit the proper amount of air and in fine streams beneath the fire. The fire floor is level from front to back. The flames have nothing in their path until they strike the protecting wall in front of the blowoff pipe. The burner is introduced through an orifice about 2 in. above the fire floor. With this method, a maximum of steaming capacity is obtained without any danger whatever of burning the boiler, there being no blast effect and no possibility of localizing the heat. Whatever type of burner is used, however, a dutch oven is a good investment.

MEXICAN OIL

The past year or two there has been a great deal of Mexican oil burned in this vicinity. When this oil is used, a target of any sort is out of the question, as a deposit rapidly accumulates upon it and has to be broken loose every 30 or 40 min., or it will deflect the blast from the burner against the boiler or some other point where it is not wanted. Mexican oil is heavy and of a jet-black color. Heating it is profitable in warm weather and necessary when it is cold. But this is accomplished practically without cost as the exhaust from the oil pumps is ample for the purpose.

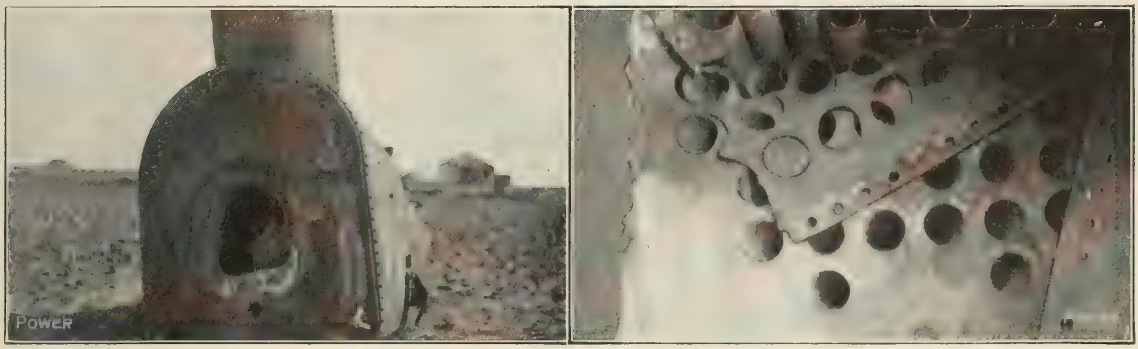
It is advisable with any grade of oil, and especially with Mexican oil, to reduce the lift of the pumps as much as possible. If the elevation of the unloading track will permit, the storage tank should be placed above the level of the pumps and a suction pipe of ample size provided. Circumstances might justify elevating the tanks anyway, and the use of a pump to unload the cars.

In our plant the storage tank is located about 100 ft. from the pumps and about half above ground. If the tank is half full or more, the oil flows to the pump, and never has to be lifted more than 4 ft. Even then the pump does not have to lift cold oil. A 2-in. suction line runs from the bottom level of the tank to a small pit in the boiler room containing a heater made out of a piece of 6-in. pipe about 3 ft. long. This is capped at the ends and supplied with a few coils of 1-in. pipe through which the exhaust steam from the pump is passed. As the oil flows through the heater at a comparatively slow rate, it is warmed well up toward 100 deg. by the time it reaches the pump. This suction-line heater is called the secondary heater. A larger one in the discharge line from the pumps is called the primary heater. The exhaust passes through this one first and then to the secondary heater. The oil leaves the primary heater at about 120 deg. This insures an even flow of thin oil to the burners. A relief valve is placed in the discharge line, allowing all surplus oil to flow back to the suction line. Both heaters should be bypassed so as to allow for repairs without interruption of the service.

When continuous service is imperative, everything, as far as possible, should be in duplicate. It is usually wise to even have two suction lines all the way from the storage tanks, and duplicate discharge lines to a point as close as possible to the burners.

Pieces of waste and other trash will find their way into the storage tanks and eventually get into the pump valves, burner valves or the burners themselves. It is well to provide a strainer of some sort to intercept these annoying bits of refuse, for it requires expeditious use of the monkey-wrench to change burners during a peak load without dropping the steam pressure.

As a rule, trash goes through the pump valves all right, and lodges in the burner valves or burners. Therefore, strainers are usually placed in the pipe line between the pumps and burners and are usually arranged so they can be cleaned by merely opening a drip valve at the bottom and turning steam on at the top; the oil having first been cut off. This is the work of but a moment and insures a clear line and good service.



External View and View Inside of Firebox of Exploded Boiler

To return to the subject of Mexican oil, it may be said that it is a great soot producer. If it is used, the boilers should be equipped with soot blowers, and these made use of every two hours. Besides being a soot producer, it is nasty and unpleasant to handle. However, its lower price justifies its use and it is also much less liable to explode in the furnace in case the fire goes out and then reignites, than are the lighter Texas oils.

Avoiding Furnace Explosions

To avoid an explosion in lighting an oil fire, before applying the torch open the damper and ashpit doors and turn on the steam to clear the pipe and burner of water. When dry steam comes, shut off the steam and place a piece of burning waste a couple of feet in front of the burner; turn on the oil a little until it ignites, and afterward turn on the steam. In case the fire goes out, the steam should be immediately turned off; the oil will then ignite without explosion. But even in doing this the operator should guard his personal safety, as an explosion might occur just as he reaches the steam valve. Some engineers have placed doors in the side wall, opening upward, and consequently held shut by their own weight. If an explosion occurs, these doors open and relieve the pressure, thus saving the boiler walls. But it is obvious that if such an arrangement is resorted to, it should be carefully installed so as to prevent air leakage.

Unusual Features of a Boiler Explosion

Boiler explosions in general have a similar combination of conditions preceding them, but the results differ. In the case of the locomotive-type boiler of an oil-drilling rig, illustrated, the contributory causes were as follows: There was no glass gage. The fireman had other duties, and on returning he found only dry steam in the lower gage cock. He started the injector and returned to his other work. In a short time the boiler exploded. The somewhat unusual features are:

No one was injured.

There were no sheared rivets, the sheets tearing everywhere, except where the crown and flue sheets joined, where the rivets pulled out of both sheets.

The stay-bolts in the crown-sheet, of which there are forty-two ¾-in., must have all pulled loose at once, letting it down evenly as it is flat (being flat to begin with); the edges are turned up, forming a rectangular tray.

Twelve of these crown-stays extended up to the top of the dome which was flat. These jerked the top of the dome down 2½ in. so suddenly as to break all the pipe connections, leaving the steam gage, safety valve and piping lying about the immediate vicinity.

The firebox was of the open-bottom type, and the force of the explosion hurled the boiler about 260 ft. sidewise instead of end over end.

* * *

Highest Power Locomotive—The most powerful locomotive unit yet built has recently been completed for the Erie Railroad by the Baldwin Locomotive Works. It develops a tractive force of 160,000 lb., accomplished by placing eight of the 24 63-in. driving wheels under the tender, making the weight of the latter available for adhesion. The locomotive is built after patents granted to George R. Henderson, consulting engineer, Baldwin Locomotive Works. The frames are vanadium steel castings of the unusual width of 6 in. The engine excels in efficiency for slow, heavy work, measured largely by the proportion of the total weight available for adhesion, 90 per cent. being in this case carried on the driving wheels as against 65 per cent. in a large Mallet. The total weight of the engine is 830,000 lb., of which 743,000 lb. is on all the driving wheels.

The Isolated Plant*

By W. A. Starkweather

SYNOPSIS—A plea for more thorough systems of record and cost keeping in isolated power plants so that engineers may check the calculations of the central-station agents in times of proposed changes of the source of power. A plant has a cross-compound engine directly connected and operates in connection with a vacuum-heating system. The engine is operated continually on a compromise terminal pressure basis, depending on the outside temperature, but is always under more or less vacuum. The only heat loss is through the flue gases and condensing water.

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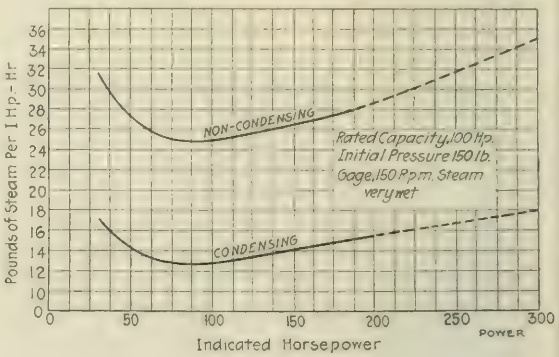
The central stations in all large cities are of high capacities, run at high efficiencies and are usually operated by the most skilled men obtainable. Their entire business is the production of power at the lowest possible cost, and their efforts are united and concentrated to this end. They are assisted by a complete contracting and selling force of well organized men, keenly active and intent on securing all the business in sight. Moreover, their financial, political and social affiliations constitute a ramification of interest which frequently takes the problem out of the domain of engineering into one of convenience, policy or business management.

The two extremes of the central station are not debatable. There are some plants where purchased current is warranted and advisable. There are other plants where central current has no possible advantage. An example of the first would be a warehouse in which there is a small lighting load but occasional heavy elevator loads. This plant must be sufficiently large to carry the maximum load and be in commission and possibly in operation at a small fraction of its total capacity. An example of the second would be a dyehouse or bleachery, in which the load is steady and all exhaust steam is utilized. Conditions might be such that the plant could be a complete high-pressure turbine condensing installation, competing in every detail with the central station in low power-cost production. It is neither of these two extremes that are particularly interesting at this time, but the vast middle ground, constituting probably 95 per cent. of the plants where there is a combined load of power and light, several units in more or less good condition, where exhaust steam is utilized or where high-pressure steam is necessary for process work. There is no hard-and-fast rule for taking up these questions and arriving at a definite and final answer. No man can walk into such a plant and make a snap decision that will be anywhere nearly accurate. Each case, being peculiar in itself, requires special study. It is here that operating engineers usually lose ground. They may have the best intention; they may be careful, faithful and experienced, but if they are not actually prepared with reliable operating costs and such data, they cannot meet the central-station claims when the question arises as to whether the plant shall continue to furnish power or whether the power shall be purchased. Wild talk, prejudiced statements and harangues are utterly valueless.

Taking an existing plant, one of the first things to determine is the load curve in horsepower- or kilowatt-hours per day for various seasons. If the load is fluctuating, this should be determined by a recording wattmeter or, at the least, by ammeter and voltmeter readings taken at regular intervals of 5 min. or so, for at least an hour; preferably as frequently and for as long a time as can be spared. Do engineers accurately know their daily kilowatt-hour loads? This brings us at once to the question of the proper size of unit to use for each load and requires the steam curve of the engine. Such a curve is shown in the accompanying figure. If electric elevators are on the system with their excessive starting load, it may be necessary to run several engines at light load to take care of the maximum, which may come on at any minute and require the ultimate capacity of all units, or one unit for the elevators, another for light, etc. These elevators vary in design and the power depends on weight, speed acceleration and drive. Generally 4 to 6 kw. are required per ton-mile, but this is only approximate. Variable-speed feed pumps are now built of such high efficiency that the old claim of enormous steam consumption for hydraulic elevators is not convincing.



Performance Curves of Engine

The latent heat of exhaust steam, amounting to about 1000 B.t.u. per pound, carries an immense amount of energy which it will give up in the form of heat. A full-stroke elevator pump exhausting through a heater in which all the steam is condensed, the heat being imparted to the feed water, has a high thermal efficiency.

There should be means for weighing the coal and ashes and for measuring, at least by a meter, the water required by the boilers. These are the three fundamental measurements that should be made in any steam-power plant.

An employer should have no objection to telling the engineer the price paid for coal, and if the engineer has a method of testing various coals on a cost basis, he will be interested, for any intelligent owner is usually interested in dollars and cents. For instance, with coal at \$4.50 per short ton and an evaporation of 10 lb. from and at 212 deg. F., the cost of 1000 lb. of steam is about 22½c. If one can obtain coal at, say, \$3.50 per ton and get an evaporation of 8½ lb., the cost per 1000 lb. of steam will be about 20½c., or a saving of nearly 10 per cent. This may mean handling an inferior coal and more ashes, and the use of such coal might possibly be limited by the capacity of the boilers, but changes might be made in the grates or in the draft which would secure better furnace and boiler efficiency. In general, the higher the furnace temperature up to the fusing point of the ash, the better. There is no apparent reason why the employer should not insist on buying coal on an evaporative basis with a penalty for nonfulfillment, but this requires an engineer who knows how and who will make a test.

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*From a lecture before Providence, R. I., N. A. S. E. No. 1.

An engineer should be prepared to urge the advice of a reputable consulting engineer whenever conditions are more than the engineer can handle. He will be helped more than hurt by this attitude.

The central station can produce current, so far as power-house costs are concerned, cheaper than the independent plants, and the reasons are obvious. There are the advantages of high load factor, low fuel costs, due to large contracts and bulk shipment; the handling of coal by mechanical means and the use of the most modern and efficient equipment throughout. Power-house costs are well below ½c. per kw.-hr. In railway power houses, the coal consumption is about 2 lb. per kw.-hr., everything included. Can engineers of isolated plants show records of less than 4 or even 5 lb.? When it comes to the distribution and utilization of the current, the losses in transmission and transformation amount to 25 or even 50 per cent., increasing the cost to the consumers to about ¾c. per kw.-hr. There must then be added to this net cost the overhead charges and other expenses of the central station, and these are often heavy, possibly bringing the charge for current up to, say, 1½c. per kw.-hr. Moreover, most central companies can only sell current at this price during certain periods of the day and for certain load characteristics and under certain forms of contract. I believe the majority of plants throughout New England pay more than 2c. net per kw.-hr. for purchased current. I am not now considering published schedules or the rates controlled by the state authorities, but the net costs known at several city plants. The question is, therefore, can the independent plant produce power for approximately 2c. per kw.-hr., or less, all charges included? No definite answer can be made which will hold in all cases, but, in general, this is possible.

The cost of coal is constantly increasing, while its evaporative power is possibly decreasing, due to poorer grades and higher ash content. The cost per thousand pounds of steam is, therefore, going up, all of which tends to increase the cost per kilowatt-hour.

Few plants utilize all of the exhaust steam either in winter or in summer, since the heating and lighting loads do not run parallel and exhaust steam is constantly being lost. The central plant does not operate this way, but every heat unit is caught. During cold weather, in the morning, the heating load at the plant may be equal to or even greater than the lighting load, but in the late afternoon the lighting load runs far above the heating load and, in general, is higher throughout the day, so that steam is constantly wasted to the atmosphere with all its latent heat not utilized. A recent high-class installation in a department store in Boston exhausts a great amount of steam throughout the day, even in the coldest weather, and it is a waste which in future will not be permitted. Even this plant is generating current for less than it can be purchased. Eventually, isolated plants will be run condensing in summer, fall and spring, even when natural-draft cooling towers on the roofs are necessary, and run noncondensing only when all the steam is needed for heating.

There is a plant in which the engineers have carefully worked out this problem and where no exhaust steam is wasted at any time of the year. The plant consists of a compound direct-connected condensing Corliss engine. The vacuum steam-heating system may be connected in with the condenser by means of a differential bypass valve which takes condensing water from the bay. There is a primary heater in the main exhaust and a secondary heater to take the exhaust from the pump. During the summer the engine exhausts directly to the condenser and full vacuum is used. As cold weather approaches, the steam is exhausted through the heating system and the vacuum is reduced to about 20 in. The steam still gives ample heat for two buildings which have many floors, totaling several acres. During the winter weather, the engine runs under a vacuum of only 10 or even 5 in., and on certain days, fortunately few, when the temperature is around zero and there are high winds, the engine operates at atmospheric back pressure; that is, the engine is operated continually on a compromise terminal pressure basis, depending on the outside temperature, but always under more or less vacuum. The only heat lost is through the flue gases and the condensing water. Lynn has a most efficient central-station service, but the plant referred to produces current and heat for far less than this station can supply it.

Marine Diesel-Engine Troubles

J. T. Milton in a recent paper before the Institution of Naval Architects gave a brief account of the performance of the Diesel-engine ships that have been built to date, only those troubles being mentioned that were attributable directly to the engines. In all, twenty-four vessels were mentioned, of which fifteen have reported troubles of more or less serious nature, the remaining nine apparently having, so far at least, a clean record.

Air-compressor troubles head the list, next to which comes cracked pistons due to faulty circulation of the cooling water as a result of scale or restricted passages. There were two of three cases of cracked cylinder heads and water jackets, due to the same cause; the scale deposits on the liners permitting them to become overheated, the expansion cracking the outer jackets. Two rather serious accidents were caused by bursting air receivers. In another instance there was trouble with the exhaust valves, and in still another the cast-steel cylinder covers were replaced with cast-iron ones.

One of the air-compressor accidents happened on the Swedish vessel "Suecia" when off the coast of Brazil. In this vessel the air is first compressed to 300 pounds by a two-stage air compressor, driven by an auxiliary Diesel engine, and is delivered to large receivers. At this pressure the air is used for starting, but for fuel injection it is taken from the receivers and further compressed to about 1000 pounds, at which it is cooled and stored in small receivers.

It was noticed during the voyage that an abnormal quantity of lubricating oil was passing through the compressor and being blown out through the drains in the receivers. Also the cooler pipes, through which the air had to pass, had on several occasions become partly choked with greasy matter. They had been cleared by disconnecting and heating red hot, thus burning the grease, then blowing out the residue with compressed air.

An examination after the accident showed that an explosion had occurred first in the pipe leading from the air cooler to the high-pressure receiver, this pipe being burst in two places. The flame then passed the valve connecting the pipe to the receiver, melting a groove in it, and entered the receiver which in turn burst. The engine room was filled with smoke, which indicated combustion of oil and was evidence that the accident had not been due merely to overpressure as a result of pumping too much air into the receiver.

Another case of particular interest was cited. The "Christian X," on her third voyage to Baltimore, encountered heavy weather and was forced to slow down, during which time the fuel valves became damaged. As the oil used was easily ignitable, the valve setting suitable for running at full power with slower-burning oil gave too much lead when running slowly, and damage to the fuel valves resulted.

These troubles are such as might be expected in the application of a comparatively new type of prime mover into a field heretofore given up almost exclusively to another form of power. They should not be construed as necessarily detrimental to the progress of the Diesel engine in marine work as these problems will work themselves out in time, and it is only through such troubles that perfection is approachable.

*

Engine-Speed Variation

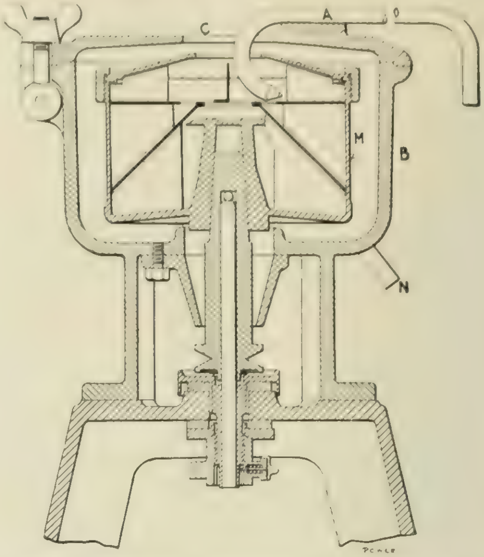
The speed variation of an engine that drives a single generator is not ordinarily a source of trouble, because under such circumstances it is the practice to keep the voltage normal by adjusting the field rheostat. Where compound-wound generators operate in parallel but are driven from different engines, one of which governs much more sluggishly than the other, equalization of the total load between the two is apt to be affected temporarily, and where the speed decrease, due to load, is a greater percentage of normal speed on one engine than on the other, equalization will be permanently affected.

An inspector was called to find out why two generators failed to divide the load proportionally within guarantees at all loads. Compounding curves were run on both machines and, roughly plotted as they were, they compared deceivably well with each other and speed variation was not suggested; but on comparing the curves with the original compounding curves run at the factory one of them was found to be much flatter than it should have been. At this juncture, the operating engineer imparted the welcome tip that he did not think that the speed held up on one engine as well as it did on the other; a test proved this to be true. The total variation on one from no load to full load was about 3 per cent. and that of the other exceeded 7 per cent. but was easily improved, after which equalization was satisfactory at all loads. In other cases, however, a difference in the percentage speed variations of two engines has actually improved the equalizing characteristics.

Atom Centrifugal Oil Purifier

This machine, by centrifugal force, separates impurities from thick or thin oil, also water from oil.

The purifier has a cylinder *M* which contains the necessary filtering surface for removing the coarser particles in the oil to be purified. The clean oil then runs out of the pipe *A* at the top of the machine, the foreign matter being discharged from the casing *B* through the pipe *N*.



Section through Centrifugal Oil Purifier

The inner cylinder is revolved at 5000 r.p.m. and a pressure of 118 lb. on the oil is created during the operation. Dirty oil is fed in through the top *C* of the purifier from a small tank into which the oil is returned after being used in the engines, pumps, etc.

This purifier is made by N. A. Sansteby, 213 Lloyd St., Grass Valley, Calif.

*

Frictionless Bronze-Bearing Tests

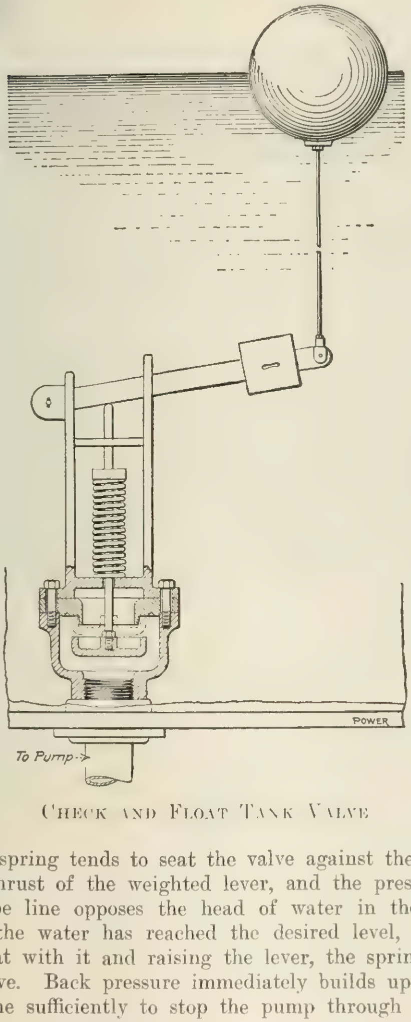
Tests have recently been conducted by the American Metal Co., Pittsburgh, Penn., to determine the efficiency of a bronze journal bearing composed of 65 per cent. copper, 30 per cent. lead and 5 per cent. tin, treated in crucibles; they are solid-bronze castings requiring no babbitt surface.

In one test a 22-lb. bearing was placed under the tender of a Pacific-type locomotive. After the engine had run 51,000 miles, the bearing showed that it had worn $\frac{1}{32}$ of an inch without becoming heated at any time. Other bearings on the tender were rebabbitted six times each during the same run.

A test was made at the Soho works of the Jones & Laughlin Steel Co., Pittsburgh, where two 75-lb. mill brasses were used under the rolling table of an 108-in. plate mill, the minimum weight of which is estimated at 10,000 lb. The superintendent of the mill stated that the two brasses gave continuous service for four weeks, or twice as long as the ordinary phosphorus-bronze bearing. On account of the position of the bearing, it was impossible to lubricate the brasses during the test, other than by the graphite in the lead.

Fisher Check and Float Tank Valve

The valve shown herewith has been designed for the automatic control of water levels in open or elevated tanks or gravity systems. It is installed at the bottom of the tank and its construction permits water being pumped into or drawn from the tank through the same pipe. In operation, it combines the features of a float and check valve, and in closing it tends to cushion itself, so that the movement is slow enough to obviate water-hammer and the sudden stopping of the pump.



Check and Float Tank Valve

The spring tends to seat the valve against the downward thrust of the weighted lever, and the pressure in the pipe line opposes the head of water in the tank. When the water has reached the desired level, pulling the float with it and raising the lever, the spring seats the valve. Back pressure immediately builds up in the pipe line sufficiently to stop the pump through the action of the pump governor.

Water may be drawn from the tank through the same pipe. As soon as the pressure is relieved the pump starts, supplying the demand until consumption is stopped and then refilling the tank to the desired level. When the tank is full, fire pressure may be carried on the mains with no danger of overflowing the tank, as the pressure in the pipe line tends to close the valve. The Fisher Governor Co., Marshalltown, Iowa, has recently added this device to its power-plant specialties.

When Horse Sense and Horse Power Were Lacking

The engineer of this narrative, whom we will call Reuben, had before him the task of moving a 5x16-ft. horizontal-tubular boiler from a flat-car in the railroad yard to the plant. Reuben was poorly paid—in a word, he was a "cheap" man.

The opening exercises consisted in getting a wagon, that was wholly inadequate for the purpose intended, parallel with the flat car. The wheels were blocked fore and aft, and the horses detached and swung around to take a rolling hitch on the boiler to roll it from the car to the wagon.

Here Reuben's lack of mechanical knowledge asserted itself in a somewhat amusing way. An ordinary flat car stands about 3½ feet above the surface level, and the five-foot boiler on the car made the chain hitch about 8½ feet above the ground level. The team hitch was made of such length that the line of pull was at something like 45 degrees.

After two or three unsuccessful attempts, Reuben saw the point and lengthened out the hitch to avoid lifting the team off the ground. The boiler was then rolled on the wagon and its movement toward the power station started. It was soon stalled, however, beyond all efforts of gods, men and horses at a point where the wagon way crossed the private side track to the power station. This "plugged" the switching service, so that coal could not be delivered if Reuben did not get out of the way with his "biler" and wagon. It was a common dirt road and in its worst condition at that.

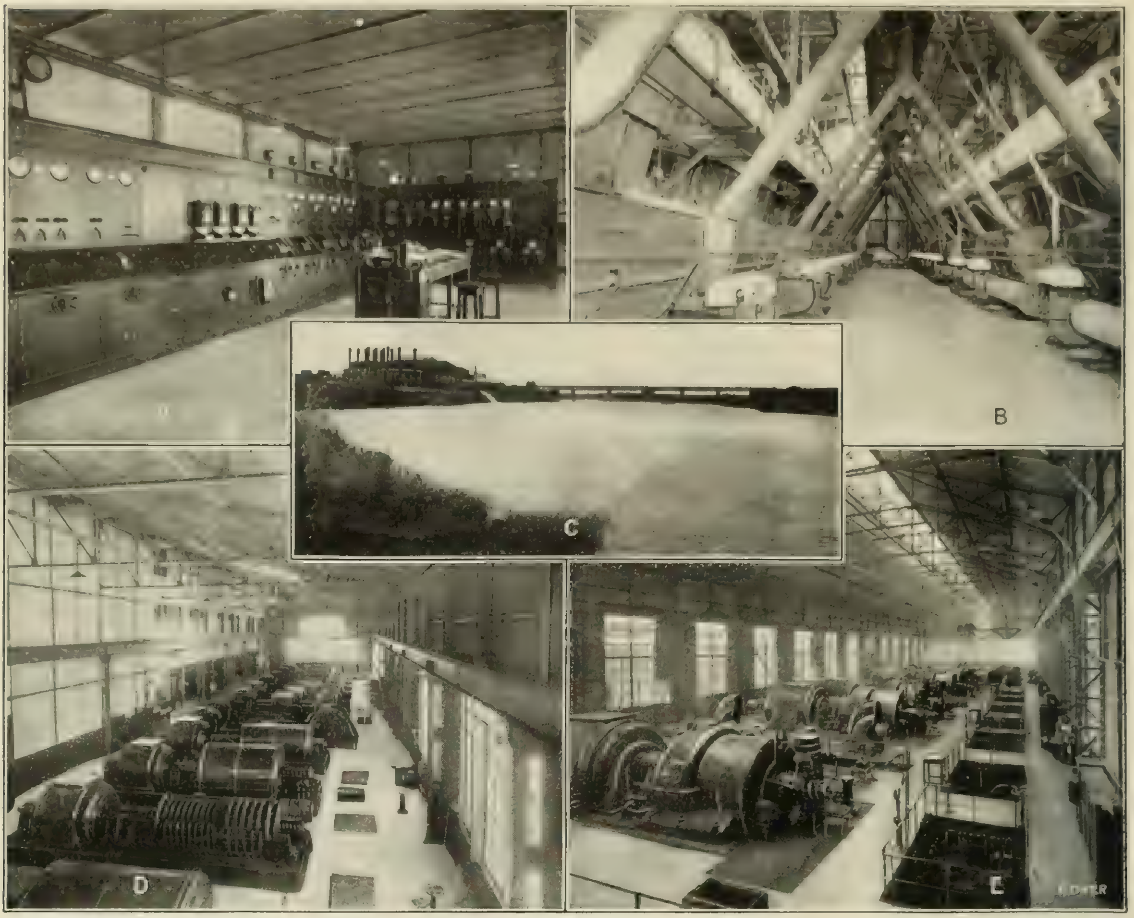
On the highway a steam road roller was at work, and it was suggested that perhaps he could negotiate for its use; it might answer as a traction engine.

The outcome was successful. The steam roller had all that it could do, and its big flat drivers went around and around without making much material progress. Then one of the wagon wheels began to exhibit symptoms of collapse, and a man with a pail of water was delegated to keep the hub well wet down to hold the wheel together if possible to the journey's end. The quarter mile to the power station was traversed in about six hours. Notwithstanding the many exciting events on the way, the wagon and its burden arrived right side up.

This shows that it is not merely time and energy that are wasted when work is done by men who have no idea of what method is. There is a considerable risk attending the careless handling of heavy apparatus, but it does not seem to appeal to the employer who hires only men who will work for small money; "cheap" men.

Incompetence in or about a power station should not be tolerated. An engineer should be able to reason quickly and logically. In case of emergency, he should be able to rise to the occasion and render good service. When employers learn the meaning of the term efficiency as applied to men as they now understand the term when it is applied to apparatus, there will be a decided improvement in the ranks of the engineering profession.

South African Power Plants



Views of Power-Plant Installations in South Africa

A. The switchboard at the Rocherville power station, Victoria Falls Power Co., Ltd. B. Rocherville power station boiler house, automatic stokers feeding small nut coal. C. View of Vereeniging station of the Victoria Falls Power Co., 90 miles from Johannesburg on the Vaal River. D. View of the Robinson central station of the Victoria Falls Power Co. The nearer machines are 4000-hp. rotating air compressors with the cover removed to show the cooling arrangement of the water-tube jackets. E. Engine room at the Rocherville station, Victoria Falls Power Co., showing the 5000-hp. rotary generators with air compressors at the far end.

The Victoria Falls & Transvaal Power Co., Ltd., was organized in 1906 to supply power for South Africa and Rhodesia and acquire the concessional rights to develop the Victoria Falls. In 1908 the group of mines controlled by the Rand Mines, Ltd., and Eckstein & Co. changed over to electric drive and, in addition, compressed air was required. This led to the formation of the Rand Mines Power Supply Co., and, although these companies are working under separate license, they are practically one organization.

The peak load of the combined undertaking has reached 88,000 kw. The power supplied is at 2100 and 525 volts. The necessary step-down transformers, etc., are provided by the power company, the consumer supplying the substation building and paying the power company a sum equal to 2 per cent. of the power bills to cover the losses in the transformers. The area supplied is confined within a strip about two miles broad and 50 miles long, running east and west through the mining district.

At all the stations steam turbines and alternating generators are used, producing 50-cycle, three-phase current; step-up transformers raising the pressure to 10,000, 20,000 and 40,000 volts. The main transmission system involves 40,000 volts overhead lines, and where the load is most dense, the system has two rows of towers, each being arranged to carry two circuits.

There are two central air-compressing plants serving the mines, and are built about 14 miles apart; the total length of the pipe line is about 20 miles, varying from 9 to 24 in. in size. The rotary compressors are rated at about 3500 kw. each and are said to be the largest yet constructed. The delivery pressure of the air has to be about 100 lb., the average drop from the compressors to the consumer being not over 6 lb. There are 4000 joints designed to allow for contraction and expansion of the pipe lines.

Editorials

Water Rights

The Constitution of California declares that water appropriated for sale is appropriated to a public use. By statute the County Boards of Supervisors are authorized to fix rates so that the returns to the companies furnishing the water shall not be less than 6 per cent. upon the value of the canal, ditches, flumes, chutes, and all other property actually used and useful to the appropriation and furnishing of such water.

Some of the companies, not content with a profit of not less than 6 per cent. on the money actually invested, claimed that they were entitled to an equal percentage upon the value of their water rights, and the Supreme Court has just issued a decision upholding that contention. As this decision will apply to water rights granted for power purposes, it will be of wide effect, and should stiffen the conditions under which such water rights are surrendered to private or corporate control.

The Reading Habit

Commenting on getting the habit of reading, the *Saturday Evening Post* says: "Hardly any other habit will stand a young man in better stead than a reading habit, both for what it includes and what it excludes. Of all habits it is the pleasantest, the cheapest and the most dependable. You can indulge it regardless of weather, seasons and location. For almost any intelligent young man it is an easy habit to form. That and a habit of physical exercise will make nearly any man fireproof against chronic dissipation."

If all this may be said of a habit of general reading, now much more might be added for a habit of reading along the lines of one's work—reading that is akin to, if not quite, studying. The first, a general reading habit, may be "the pleasantest, the cheapest and the most dependable." The habit of selected reading or studying is all of that and more—it is the most profitable.

By general reading one may acquire culture, may make himself so well informed on miscellaneous topics, that he is a delightful conversationalist and an agreeable companion. On the side of the things excluded, he may avoid habits that are extravagant, and even positively injurious. Again we say, he may equally do so with reading to improve his knowledge of his calling, and all those traits that make him companionable to his fellows interested in the same field of effort will be incidentally developed.

General reading of a proper kind is elevating and does make the reader a better man, but technical reading makes him a better engineer. Entirely apart from the reward of a more responsible position at a higher salary as a consequence of greater knowledge, technical reading pays when it brings a man a better understanding of all that pertains to the place he is now filling, when it enables him to take part intelligently in discussions on engineering subjects. The respect of others and his self-respect both increase.

The other habit recommended in the quotation, physical exercise, needs no endorsement to engineers. They automatically get plenty of exercise—or most of them do. So we would concentrate on the plea for the reading habit even if we do appear to be actuated by a motive of self-interest. To be sure, if the reading habit became extinct there would be little use for either papers or editors. Our service can never avail much if what we print is not read. "You can lead a horse to water, but you can't make him drink." We can scour the field and corral in these pages what we believe it is for the readers' good to know. That is as far as we can go. You must take the receiver off the hook to get our message over the telephone; you must take off the wrapper and open the paper to get our message through POWER. The same is true of those books on your shelf and any other literature you neglect.

P. S.—Since we wrote the above, it has dawned on us that those who will read this editorial do not need it and those who need it will not read it. Then what did we write it for? Perhaps it was in the hope that those who read it will show it to those who need it. Will you?

Vocational Training

In a short time, thousands of boys and young men will have been graduated from the grammar and the high schools, the great majority of whom will have to seek work at once. How many have been fitted by what they have learned for any kind of work? How many know what they really want to do?

There are a few cities in which the "continuation-school" method is in vogue, and it has proved its practicability. By this method, the young employee is allowed time during his working hours to pursue those studies which will ground him in his chosen vocation, will create a desire of understanding what he is doing, why he is doing it and will show him that his advancement greatly depends upon a sound knowledge of his work.

While we look to the boards of education for the installation of the continuation school, its adoption mostly depends upon the interest taken by the employers and the public, as it will be supported by them jointly.

But, says Arthur D. Call, a well known educator, the boy must be studied as well as the vocation if the schools and the workshop are to properly dovetail. We quote:

> The one outstanding lack in our American education is the general failure to take into consideration the personal equation. Pupils are educated in a haphazard way, with no effort to determine in which direction their talents may lie.
>
> Their qualifications now can be determined with scientific exactness. Educators generally fail to recognize even the broad and easily determined facts about a child. For instance, it is generally known that there are two great classes of children, the object-minded and the idea-minded. One class thinks in objective terms, the other class thinks in words.

The Census Bureau states that but four per cent. of our people are in professional service, sixteen per cent. follow the trades, thirty-six per cent. are farmers, and twenty-four per cent. are manufacturers. These figures show roughly that the present school system is training over eighty per cent. of the pupils for about four per cent. of the opportunities. This is a most convincing argument that the schools are not doing the greatest good to the greatest number.

To provide vocational training, one state alone spends $50,000 a year on 250 children in its trade-school work. Wisconsin has 25,000 in its "continuation" schools, and, owing to their popularity, this state will have about 40,000 scholars next year. If the continuation-school idea were more generally understood, it would undoubtedly be more widely adopted.

The conditions under which many operating engineers now labor for the education denied them as boys, should prompt them to help devise ways whereby the young helpers in the plant can arrange with their employer to get time off to study. It can be done in many plants, and it is up to the engineer of today to interest his employer in this matter and find the means to make it possible for the engineer of the future to properly equip himself for his vocation.

Distilled Makeup Water

The amount above normal rating at which a well designed boiler may be safely operated depends chiefly upon the scale-forming solids and the suspended matter in the feed water. In his paper treating of the operation of the large boilers in the Delray station of the Detroit Edison Co., and read before the American Society of Mechanical Engineers at its December meeting, J. W. Parker stated that one-sixteenth inch of scale on the hot front tubes caused overheating at high ratings. It was brought out in the discussion of Mr. Parker's paper that scale of eggshell thickness and covered with mud, in tubes of a boiler driven at moderate ratings, caused serious overheating. In this latter case the feed water was taken from the Alleghany River and contained from six to ten parts per hundred thousand of incrustating solids.

In large central stations or other steam-power plants where modern practice dictates that the ratio of installed prime mover capacity to boiler capacity shall be high to minimize investment and overhead charges, the reliability of the boilers must of necessity be high, especially in plants where the units are very large, as at Delray.

In the hope of increasing the reliability factor of the large boilers under his charge, Mr. Parker stated in his paper that he seriously contemplated using distilled makeup water, believing that there is a lack of evidence that distilled water is of itself corrosive. To safeguard against against possible corrosion, however, it is intended to feed in with the water enough soft-scale-forming material to cover the heating surfaces with a thin protecting scale. In his recent talk before the Engineers Club of Boston, Captain Manning said of the scaling of boiler tubes:

". . . but the correct solution is to use water that makes no scale, purifying the water before it is fed to the boilers."

In the discussion that followed Captain Manning's talk, James D. Andrews, of the Edison Illuminating Co., of Boston, agreed that evaporators for distilling makeup water should be provided. We understand that H. G. Stott, of the Interborough Rapid Transit Co., is considering the use of distilled makeup water for the remodeled Seventy-fourth St. plant, where the boilers will be driven at four hundred and fifty per cent. rating at times and three hundred per cent. regularly on the morning and evening peaks.

All this activity shows the trend in boiler practice in large plants. Whether distilled makeup water will be advantageous or disadvantageous in such plants, remains to be proved by the results of its use in some of the plants now contemplating it.

The first thought that comes to one considering it is that it has been used in marine practice for years without giving really serious trouble. The cost of distilling makeup water is not an important consideration, for, even in extreme cases, the quantity of water will not exceed fifteen per cent. of the total and, in well conducted plants, where leakage is closely watched and minimized, it will be as low as five per cent.

⁂

After nearly a year from the time the engineers' license-law bill passed the New Jersey legislature, that body has appropriated a sum to put the license bureau in operation. A state-wide license was a mighty long time coming in Jersey, and because of this and the industrial importance of that state there is all the more reason for rejoicing. The Commissioner of Labor under whom this work will be done requests that engineers do not write for applications until the license bureau is organized, which fact will be announced at the proper time.

⁂

The "how" and the "why" should more largely govern our contributors and correspondents when writing for the paper. Complaint is made occasionally that the "blue pencil" has, in the words of a recent writer, "sadly mutilated" an article or letter. It is clearly impossible for Power to publish all our contributors would write. The best and most highly trained writers stop when they have said their say. We hope that some of our writers will strive to imitate them. Be brief, and to the point, and you will better interest the readers, and make your contributions all the more acceptable.

⁂

Our Sunday supplement writers would do well to consider the power plant as a peg on which to hang a good "human-interest" story. Handled skillfully and understandingly, it would appeal strongly to the lay reader, and incidentally give him a knowledge of the power-plant engineer's responsibility and of the public's great dependence upon him for its many necessities and its safety.

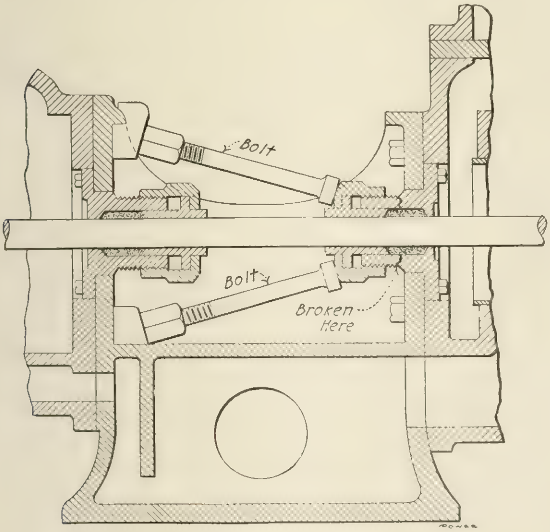
⁂

The smoke-abatement movement in England is making but slow progress, chiefly owing to the inability of its advocates to introduce a bill into Parliament this year. At times, we fret because of the "red tape" of our state legislatures, but we are not further hindered by the "private bill"—meaning a bill not proposed as a government measure. As gas is cheaper than coal, notably in London and in many provincial towns, the apparent indifference of Parliament to the abatement of smoke may be thus explained. The advocates of such a bill are hopeful, however, and intend making another effort next year.

Correspondence

Temporary Pump Repairs

The stuffing-box on the steam end of a pump was broken by frost as shown. The pump was made serviceable (and operated for 10 days until a new part was received) by inserting $\frac{1}{32}$-in. sheet packing, coated with shellac on both sides, between the broken parts. Pressure was applied by means of two bolts and nuts fitting snugly, then backing out the nuts a few turns.



Bolts in Position

FRED W. SCHNEIDER.

Clay Center, Ohio.

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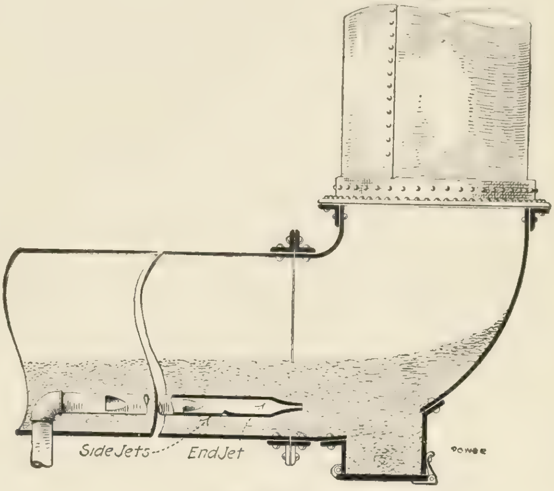
A Flue Cleaner

A certain plant had two 54-in. return-tubular boilers. The 40-ft. horizontal flue, 30 in. in diameter, was connected directly to the bottom of the 32-in. stack without any settling chamber for the soot. We had difficulty in keeping it clear enough to insure a good draft, especially in winter.

The usual method had been to clean the elbow through a small hole in the bottom every few weeks and once or twice a year have the whole crew spend a Sunday cleaning out the entire flue. This was a very disagreeable job for the men, besides depriving them of their Sunday; moreover, our draft was constantly changing. After participating in this event several times, I did the work with a blower.

I cut a piece of 1¼-in. pipe long enough to reach from the front of the flue back to the damper. Then I heated and flattened one end until it formed a $\frac{1}{16}$-in. nozzle about 2 in. wide. Every 4 ft. of its length I made jets, as shown, in groups of three, one on each side and one on the bottom, staggering them so as not to weaken the pipe. To make the jets, I first sawed into the pipe to the depth of a hacksaw blade, then hammered down the front side, forming a jet to throw the steam at about 30 deg. with the pipe. In action the steam jet would dig the soot off the walls of the flue and carry it toward the stack and out of the hole in the elbow. I put a second section between the damper and the stack, arranging valves so that they could be blown independently.

When the blower was installed the soot was nearly a foot deep in the flue as I had allowed it to accumulate as a test. With the plant in operation, two men cleaned the flue thoroughly in less than an hour, using steam at 70 lb. We always have the damper open. By opening a smoke-box door, we could get draft enough to carry the soot out of the top of the stack, but, of course, that was not advisable in the city.



Flue Cleaner

This outfit was made of old stock and the work was done by the regular force so that the cost was practically nothing. The improved combustion and the ease of cleaning were greatly appreciated by all concerned.

H. K. WILSON.

New Bedford, Mass.

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Points on Babbitting

Mr. Allen's article on page 487, April 7, 1914, should be of great service to many. That a well balanced, lead-based metal will meet all ordinary cases is not generally known, but in many cases, it will give far better results than expensive babbitt.

Salesmen are always calling one's attention to the low coefficient of friction of their wares, but is not this point under running conditions (as the shaft should not be touching the metal) governed by the lubricant?

As to pouring bearings, I prefer to use either soap o asbestos, in the form of a heavy sheet or square rope, to clay, as there is less chance of a boil through moisture. In bearings to be run in quickly and got back into service, I use a piece of thin tracing paper fastened around the shaft by strong threads, letting the ends overlap by about $\frac{1}{16}$ in. This is then well rubbed with powdered graphite after strips of asbestos have been fastened on for oilways. The shaft is lined up and the housing warmed with a blow torch. Just before pouring, a little powdered rosin sprinkled into the gate will ensure a sound casting. As soon as the metal is set the paper and asbestos strips are scraped away and the bearing surface is well oiled and liberally sprinkled with graphite. In three out of four cases, it will not heat from the start.

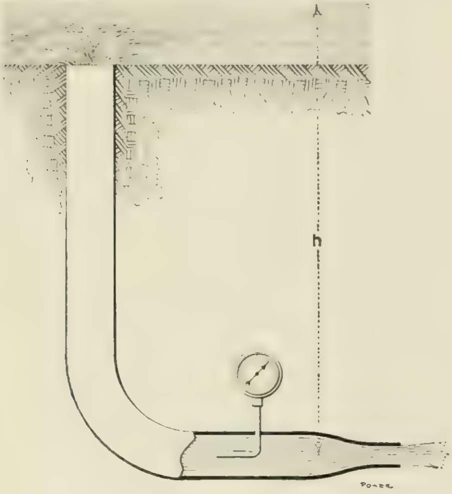
E. R. PEARCE.

Rochdale, England.

⁂

Small Water Motors

With a view to assist those interested in such problems, the writer offers a few simple rules of hydro-power development on a small scale, which also apply to the largest developments.



GAGE ATTACHED

The foot-pounds of energy in water is equal to the weight of the water multiplied by the distance in feet through which it falls, or pounds weight multiplied by feet fall equals foot-pounds, which divided by 33,000 equals the gross or total horsepower. This, however, is never realized in practice, on account of various losses. The average mechanical efficiency of waterwheels is about 75 per cent.

To ascertain the power in a small jet of water, place a pressure gage in the pipe immediately behind the jet, as shown in the illustration, and while discharging observe the pressure in pounds per square inch. This will be the effective pressure; that is, the total pressure due to the head minus the loss in overcoming pipe friction.

Multiply the effective pressure by 2.3, which will give the effective head in feet. Collect and ascertain the weight of water from the jet in one minute. If measured in gallons, multiply the number of gallons by 8.34 (the weight of 1 gal.), which will give the total weight in pounds.

Multiply the weight of water in pounds discharged in 1 min. by the effective head in feet as ascertained above and divide the product by 33,000; the quotient will be the horsepower that the jet delivers to the wheel. Multiply this last quantity by 0.75, which is a fair degree of efficiency for a small water motor, and this final product will be the useful horsepower.

It should be noted that the larger the jet used for a given sized pipe, the less the effective pressure will be and even if a larger final product is obtained, it will be with great extravagance in the use of water.

T. H. REARDON.

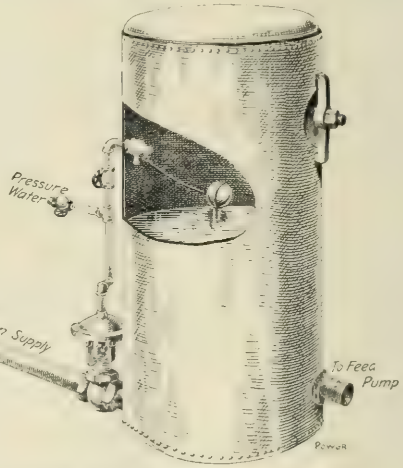
Pittsfield, Mass.

⁂

Water Control for Tanks or Heaters

The illustration shows a semi-home-made water control, which is capable of numerous modifications. The principle is that of the boiler-feed regulator. In this instance the float, or pilot, valve was an ordinary closet ball cock. The pilot, being of the smallest size, does not require a large float and therefore is not likely to collapse.

The tank was drilled at about the maximum level for the water; then the pilot valve inserted therein, and connected to the pressure water main by a ⅜-in. pipe. one branch of which was connected to the bonnet of a 4-in. diaphragm valve on the main return line. In action, when the water in the tank raises the float, and the pilot valve closes, the water pressure will then close the diaphragm valve on the main supply. If it is desired to close the diaphragm valve for any purpose without regard to the water level, it may be done by closing the upper globe valve. Likewise, if this valve is to be held open, that on the pressure water may be closed and the pressure released from the diaphragm.



PILOT AND DIAPHRAGM VALVES

When two sources of supply to a tank, such as heating system returns and makeup water are to be regulated, the makeup pilot valve should be located at the minimum level and the other at the maximum. A better form of construction, with the advantage of having all parts exterior to the tank, can be made by using a boiler feeder of the type used on cast-iron heating boilers or, still better, a regular high-pressure boiler-feed regulator for the pilot.

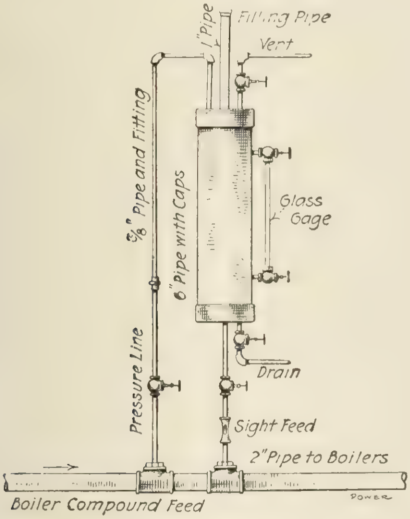
All of the parts entering into this construction are standard and procurable at supply houses. It is, therefore, not a makeshift or an apology for something else.

LEON LEWIS.

New York City.

Boiler-Compound Feeder

A boiler-compound feeder to be connected to the discharge line of the feed pump is shown in the illustration. It should be set above the feed line to get enough static head, which, plus the pump pressure will be sufficient to discharge the contents. Perhaps this is not a new idea, but it may be of value to someone.



FEEDER CONNECTED

C. T. BAKER.

Jacksonville, Fla.

Auxiliary Economy in Steam Power Plants

The article on the auxiliary economy in steam-power plants, on page 436, Mar. 31 issue, is timely. We have consistently fought for high economy in auxiliary apparatus, both as to high-vacuum and low-steam consumption. The editorial on page 452 is also appreciated. The following is the substance of a letter on feed-water heaters which we are sending to consulting engineers. There are many engineers who will not have an open heater because of oily water, and while this objection is disappearing with turbine-driven auxiliaries, this only applies to large plants.

The letter reads as follows:

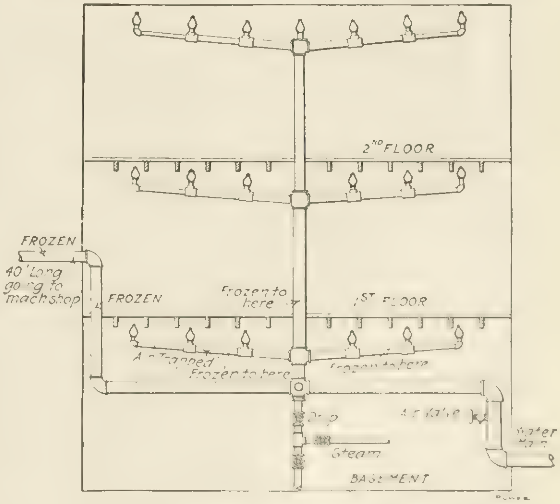
> As manufacturers of feed-water heaters of the closed type, we wish to call the attention of consulting engineers to the question of rating, or the amount of surface offered by various bidders to secure specified results with given conditions. The situation has been going from bad to worse in the past few years and the present confusion is not creditable. Heaters are rarely tested to determine satisfaction of guarantees, so that misleadng statements continue unchecked.
>
> On a horsepower basis, the surface is stated as low as 0.2 of a square foot, and as high as 0.5, the smaller amounts being claimed sufficient because of improved transmission rates due to increased water velocity (on which there is no patent), better conductivity (although with practically the same metal in all), molecular movement, stream lines, etc. While there may be a slight difference with various designs, we contend that this is not enough to warrant 250 per cent variation in surface, on which cost primarily rests. We estimate the surface as follows:
>
> W = Pounds of water per hour;
> K = The constant of transmission, 250;
> T = Temperature of steam;
> t_1 = Temperature of entering water;
> t_2 = Temperature of departing water.
>
> The formula is:
>
> $$S = \frac{W}{K} \log \frac{T - t_1}{T - t_2}$$
>
> The results from this formula confirm experience, that an approximation to within 5 or 7 degrees of the steam temperature can be reached with commercially reasonable surface, and that this is practically all that is usually obtained in any event. There is not enough final temperature difference between steam and departing water to warrant the necessary excessive surface to work to within 2 or 3 degrees of the steam. A recent case required 30 square feet for 7 degrees and 3500 square feet for 2 degrees approach to the steam temperature.
>
> This same problem has been developed in surface condensers, where heat transfer depends largely on the same elements as in closed feed-water heaters, and a safe and sane basis has been reached. We are therefore suggesting that it is well within the province of consulting engineers to specify the minimum surface allowed, with the corresponding guarantees which manufacturers will make for a given set of conditions. This is a usual procedure in surface condenser tenders, and we respectfully urge you to apply it to feed-water heaters. It will standardize practice and insure better sustained results.

W. G. STARKWEATHER,
C. H. WHEELER MFG. CO.

Boston, Mass.

Care of Sprinkler Systems

During extremely cold weather a sprinkler system, if called into use on account of fire or testing, may become frozen at exposed points before it can be drained and refilled with air. This, of course, applies to the "dry pipe" system in which the air excludes the water until allowed to escape by the action of the heat on the "automatics" in case of fire. I have found a steam connection with a drain at the lowest point the most convenient means of thawing it out. The points of caution are not to use



STEAM CONNECTION

more than 5 lb. of steam pressure, and that, for short intervals, and to drain frequently to avoid water-hammer. The condensation will be rapid and the melting ice will increase the amount of water.

When the system is cleared and again filled with air, allow it to stand for an hour before turning on the water valve in order to test for leaks. If the pressure drops it is a sure sign of leakage.

I find a small amount of ether or oil of peppermint in the system helps to locate small leaks which cannot be detected by sound or otherwise.

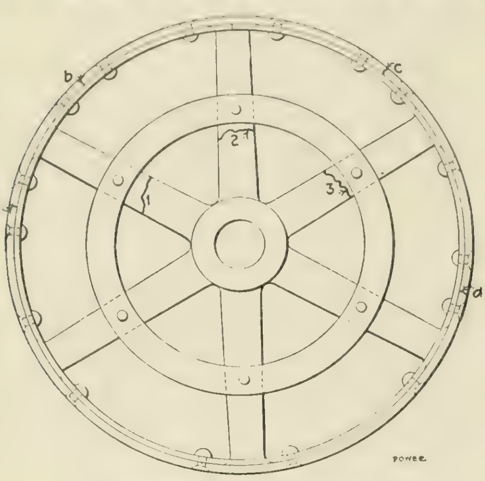
Harold Burrill.

Middleville, N. Y.

⁂

Emergency Repairs

A 16x14-in. cast-iron driving pulley for a forced-draft blower broke in four places on the rim at the points *a*, *b*, *c* and *d* in the sketch. Three of the spokes were also broken off at the points 1, 2 and 3. Repairs were made in 10 hr. by making two rings of ½x2-in. flat steel and riveting one ring on each side of the spokes with ⅝-in. rivets. The rings were heated slightly, then riveted in place quickly. When cold, the contraction drew the broken spokes together securely. We then riveted a flat sheet-iron ring $\frac{3}{16}$x6 in. on each side of the spokes with ¼-in. rivets, which completed the job.



Broken Wheel Repaired

S. E. Raymond.

Trenton, N. J.

⁂

Why the Brine Temperature Was High

When I was hired as assistant engineer on the night shift, I told the chief that I knew nothing about an ice machine. He said he would show me how to operate it and I would soon learn, so I went to work. His instructions were about as follows:

"When that pressure gage (pointing to one of several on a board) goes over a certain limit, close this valve a little; when the pressure drops, open it again; when the liquor in that gage-glass goes up or down from a string tied around the glass), either start up the pump a little or slow it down. That is all you will have to do, and if you let the rest of the system alone, you will not have any trouble."

Excellent instructions, but as the other assistant slept in the house and I could call him if necessary, I accepted the situation and made no comment. However, everything went all right, and there was no trouble that night, but the next morning I went after the other assistant for some information about the ice machine. He willingly answered every question, and in a few days I had learned a little more. We went along all right for a month or so; then the temperature at the brine pump began to rise gradually and we could not get it down. We were carrying it at about zero and it began to go up, and stay up. This continued for about a week when it got up to about 16 deg. F. Every morning the chief would ask, "Did you get the temperature down last night?" My answer, of course, was always, "No."

One morning he shook his head and said: "I don't see why you can't get it down." I promptly asked him why he didn't get it down as he knew more about it than I did, but he didn't answer. That day they were going over the system to try to locate the trouble, when somebody put a stick down in the brine tank and discovered that it was partly frozen; then, of course, the trouble was found. The brine was strengthened, and when I came in at night the temperature was down to zero, where it belonged.

Simple, but there may be others who are beginning to operate ice machines.

William N. Wing.

Brooklyn, N. Y.

⁂

Wedge Adjusting Bolt

The illustration shows a wedge bolt removed from the crosshead end of the connecting-rod on a large cross-compound, vertical blowing engine. The bolt broke through at the root of the thread, the thread forming a sort of spring. This thread was strong enough to permit the bolt being backed out of the wedge.

Broken Wedge Bolt

This, as well as other bolts, was made of machine steel. None of them gave any similar trouble on the other engines. An examination showed no shoulder on the strap or brass against which the wedge could have been pulled solid. The bolt was replaced by one of vanadium steel and it is still satisfactory and in daily service.

W. W. Pettibone.

Ludlow, Ky.

⁂

Frost Covered Generator

F. E. Albrecht's letter and photograph in the issue of Apr. 7 are very interesting. The writer has had turbo-generators in the Southern states where during the day the exhaust end of the turbine was cooler than the generator, but he has never seen such a case of frosting before. I should like to know if this frosting had any effect on the insulation, as one would expect a certain amount of moisture on the inside of the casing. It would also be interesting to know how the field excitation at the time the photograph was taken compared with that during the summer.

E. R. PEARCE.

Rochdale, England.

Care of Commutators

It is the pride of every man in charge of a generator or motor to keep it clean and free from dirt for it saves him a lot of trouble. It is also his desire to have a good gloss on the commutator and to keep it that way. On some machines the brush-holders are in line with one another, causing the commutator to wear in ridges and finally produce bad commutation. As a result it becomes necessary to turn down or grind the commutator.

After a commutator has been trued up the best thing to do is to stagger the brush-holders. This is done by moving one holder to the outside as far as desired and the next one to the inside, thus every other one is out at the edge of the commutator and every other one is at the inside. Care must be taken to allow for the end play in the machine, so that the brushes do not strike the armature or go out over the end of the commutator bars. Some operators stagger half the holders in line to the outside and the other half to the inside. Thus on a six-pole machine the three top brush-holders would be moved to the outside and the bottom three to the inside or *vice-versa.*

We have tried most every kind of a lubricant for the commutator, and have found a little vaseline on a clean rag to give excellent results. Beeswax and paraffin are liable to make the brushes stick in the holders if too much is used, as it collects on the brushes and cakes in the holders.

In case vaseline is not available a little engine oil on a clean rag gives good results, but care must be taken not to use too much as it will soften the mica.

A. G. CURREN, JR.

Kittanning, Penn.

Filing System

When I first began to keep published articles of particular interest to me, I noted on the cover with blue pencil, "Preserve." But to find an article, it was necessary to look through all the copies, and filing useless matter was also an added objection to this method.

My present method is to take from a journal only such pages as are wanted, and to file each in suitable folders and place in a case. The folders are indexed under the following headings: Steam engines, oil engines, gas engines, steam turbines, boilers and fittings, condensers, superheaters, water heaters, pumps, air compressors, intercoolers, shop methods, foundry methods and appliances, cutting tools, machine tools, small cutting tools, design.

Figs. 1 and 2 show the folder, which was made of heavy drawing paper, folded and shellacked on the outside, this gives it a hard, smooth surface, and prevents soiling. On each folder is printed in black ink the class which it covers. The inside of the cover is ruled with two double columns; the narrow columns for the number of the article, and the wide for the name and description, if any.

The filing case, Fig. 3, is made of seasoned wood, or paper board, painted and varnished, or of metal, and is not much larger than an ordinary letter file. The cover is 2 in. deep, and when thrown back exposes the folders with their classification heads to full view, thus making it easy to pick out the folder desired.

When an article is composed of two or more pages, they are fastened together at the upper left-hand corner with a clip and the number of the article is placed in the upper right-hand corner. This number is also entered in the narrow column of the index. It is not necessary to enter dates, as each page is dated.

To show how simple the system is, suppose you wish to know something about a gas engine, of piston design. You pull out the folder marked "Design," and glance down the index until you find the article. If you were looking for types of gas-engine pistons, instead of something strictly on designs, you would look through the index of the folder marked "Gas Engine." The information, if you have it at all, will surely be found either in the "Gas Engines" or "Design" folder. It is seen that if care has been exercised in classifying, the articles desired can be quickly found.

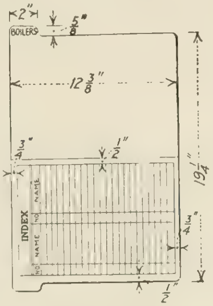


FIG. 1. FOLDER OPEN

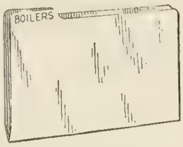


FIG. 2. AFTER FOLDING

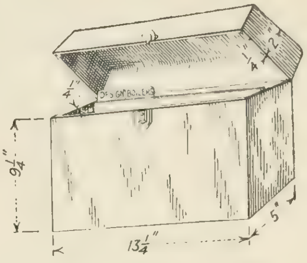


FIG. 3.

FOLDERS AND CASE

New folders can be added from time to time. At the end of a year you will have a valuable collection with which you would not care to part.

C. R. COURTENAY.

Watertown, N. Y.

To Make a Tee Square

After making a drawing board and triangles for myself, I bought two 12-in. rulers to make a tee square. I cut one in half and fastened one of the pieces to the full-length ruler with small brass screws. Care was taken to get the head square and true. I now have a neat, graduated tee square which cost only a trifle.

R. G. CURREN.

Kittanning, Penn.

Engineers' Study Course

Elementary Mechanics--XII

Machines

A *machine* is a device by means of which some form of energy is converted into useful mechanical work, or it may be a device whereby a small force may be used to balance a greater force without any work being done by either force. Only machines of the latter type will be discussed at present.

At some point of the machine a force is applied which is utilized in balancing a greater force at some other point in the machine. The force applied is generally spoken of as the *power* or the *effort*, and the force which is balanced is called the *weight* or the *resistance*. The term power, strictly speaking, means the time rate of doing work and as work does not enter into the present discussion the term effort will be used in the consideration of these elementary forms of machines.

Levers

Perhaps the simplest form of a machine is the *lever*, which consists of a bar resting on a fixed point or axis. The fixed axis is called the *fulcrum*, and the distance from the fulcrum to the points of application of the effort and the weight are called the arms of the lever. Thus Fig. 45 represents a lever commonly known as the crowbar or pinch bar. In this case the line DE represents the lever; the point C is the fulcrum; the force P is the effort and W is the weight or the resistance to be balanced. To find the relation between the effort P and the weight W, take moments about the fulcrum C. Thus

$$P \times B = W \times A$$

or

$$P = \frac{W \times A}{B} \qquad (14)$$

The reaction R on the fulcrum of the lever is equal to the sum of the effort and the weight, or expressed as an equation,

$$R = P + W \qquad (15)$$

Example: In Fig. 45, if the distance $A = 4$ in. and the distance $B = 48$ in., what weight W may be balanced by a man exerting an effort of 75 lb. at the point E? This problem is solved by applying equation (14). Thus,

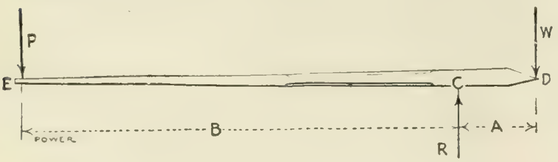


Fig. 45.

$$P = \frac{W \times A}{B} \text{ or } W = \frac{P \times B}{A} = \frac{75 \times 48}{4} = 900 \textit{ lb.}$$

The reaction R on the fulcrum C is the sum of P and W or equals

$$900 + 75 = 975 \textit{ lb.}$$

The ratio of the lengths of the arms of the lever is called the *mechanical advantage* of the lever, which, in the above case, is $\frac{48}{4} = 12$. If the length B were smaller than the length A there would be a *mechanical disadvantage*.

Levers are usually divided into three classes, depending upon the location of the effort and the weight relative to the fulcrum. In a lever of the *first class* the *effort* P and the *weight* W are on opposite sides of the fulcrum, as shown in Fig. 45.

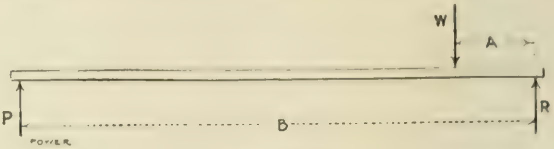


Fig. 16.

In a lever of the *second class* the *effort* P and the *weight* W are on the same side of the fulcrum, the effort being the furthest from the fulcrum, as shown in Fig. 16, where P is the effort, W is the weight and R is the reaction at the fulcrum, which, in this case, is the difference between the weight and the effort, or,

$$R = W - P \qquad (16)$$

In a lever of the *third class* the *effort* and the *weight* are on the same side of the fulcrum, the weight being the furthest from the fulcrum, as shown in Fig. 47, where W is the weight, P is the effort, and the reaction R is the difference between the effort and the weight or,

$$R = P - W \qquad (17)$$

Illustrations of levers of the first class are the crowbar, a pair of shears, the oar of a boat, a claw hammer, etc. A good illustration of a lever of the second class is the wheelbarrow. Here the axle supplies the fulcrum; the effort is supplied by the man at the handles; the weight is the load plus the weight of the wheelbarrow assumed concentrated at the center of gravity of the two. A safety valve of the form shown in Fig. 48 is an example of a lever of the third class, for in this case the effort is the total pressure of the steam on the valve and the weight or resistance is the ball placed at the end of the lever. If the weight of a lever is small compared to the forces acting on the lever, it may be neglected, but in cases such as a safety-valve lever its weight must be taken into account. This may best be illustrated by an example. Thus in Fig. 48 assume the diameter of the valve to be 3 in. and let $L = 30$ in., $C = 3$ in., the weight of the ball $W = 70$ lb., the weight of the lever, $w_1 = 12$ lb. $l = 10$ in. and the weight of the spindle and valve, $w = 6$ lb. What steam pressure will be required to raise the valve from its seat?

Let p be the desired steam pressure in pounds per square inch. The area of the valve equals $0.7854 \times 3^2 = 7.07$ sq.in. and hence the total steam pressure P acting on the valve equals $7.07 \times p$. For equilibrium to exist the algebraic sum of the moments of all the forces about the point A must equal zero. Thus,

$$w \times C + w_1 \times l + W \times L = P \times C \qquad (18)$$

or

$$6 \times 3 + 12 \times 10 + 70 \times 30 = 7.07 \times p \times 3$$

or

$$21.21\ p = 2238 \text{ and } p = 105.5 \text{ lb. per sq.in.}$$

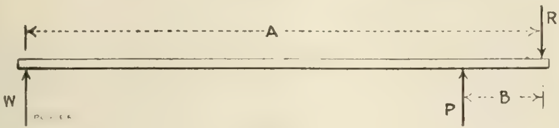


FIG. 17.

Hence a pressure of not less than 105 lb. per sq.in. will be required to raise the valve from its seat. In this problem the pressure or reaction at the pin A equals $P - w - w_1 - W = 746 - 6 - 18 - 70 = 652$ lb. As a general rule the distance l will be about $\frac{1}{3}$ the distance L. However, if desired, the distance l may be determined by taking the lever apart and finding the point D at which the lever will balance.

Still another illustration of a lever of the third class would be the rocker-arm of the Corliss valve-gear of a horizontal type of engine. Here the fulcrum is located at the pin bearing of the lower end of the rocker-arm, the effort is the thrust of the eccentric rod, and the weight is the pull in the reach rod.

The various forms of bell cranks illustrate types of bent levers and the relation between the effort and the weight may be figured as above.

WHEEL AND AXLE

Another common form of machine is the *wheel and axle,* an example of which is the ordinary hoisting drum used in various kinds of construction work. Thus in Fig. 49 let a force P be applied at the handle A of the drum or wheel to overcome the weight W acting at the circumference of the axle whose radius equals R. To find the relation between P and W, take moments about the center O of the axle.

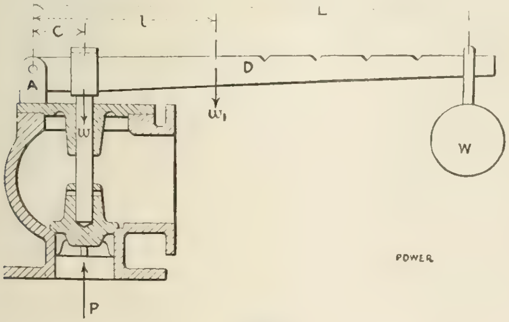


FIG. 18.

Thus

$$P \times L = W \times R \text{ or } P = \frac{W \times R}{L} \qquad (19)$$

Example: What force P must be applied to overcome a weight W of 500 lb. acting at the circumference of a drum 8 in. in diameter, if the distance from the handle to the center of the axle is 20 in.? In this case $L = 20$, $R = 4$ and $W = 500$; therefore

$$P = \frac{W \times R}{L} = \frac{500 \times 4}{20} = 100$$

STUDY QUESTIONS

51. What weight may be balanced by the use of a crowbar if the fulcrum be located 3 in. from the *c.g.* of the weight, and a man exerts a force of 75 lb. at a distance of 48 in. from the fulcrum?

52. The distance from the axle of a wheelbarrow to the *c.g.* of the total load on the wheelbarrow is 12 in. The distance from the *c.g.* of the load to a point on the handle where a man applies a pull of 60 lb. is 40 in. What load can be balanced by the man?

53. In the above problem, find the pressure of the wheel on the ground when the man supports the handles.

54. In Fig. 18 $C = 1\frac{1}{2}$ in., $l = 15$ in., $w_1 = 25$ lb., $w = 10$ lb. and the diameter of the valve is 4 in. If the steam pressure in the boiler is 80 lb. per sq.in., at what point must a ball weighing 100 lb. be placed so as to prevent the valve from lifting?

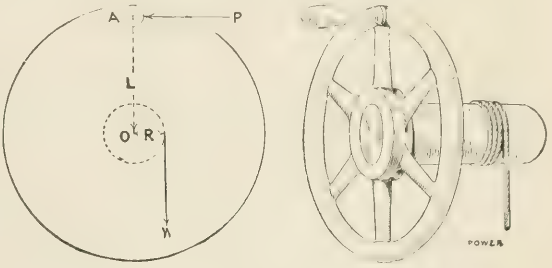


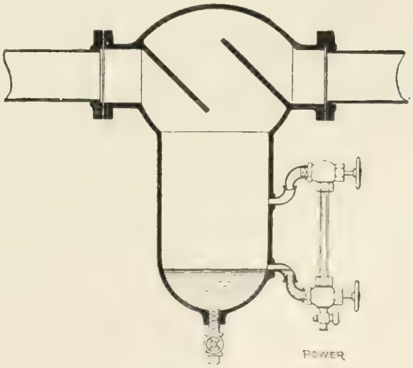
FIG. 49.

55. What weight W may be balanced by the application of a force P of 80 lb. when $L = 18$ in. and $R = 3$ in. (see Fig. 49). Neglect all losses.

⁂

Separator Gage Glasses

A gage glass on a steam separator connected up as illustrated cannot have a current of steam through it. If the readers of POWER who have separators in which it is difficult to keep a glass would try this and report results, it would help to decide if it is the current of steam which causes them to break. The lower end of the glass is water-sealed.



GAGE-GLASS CONNECTIONS

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The Westinghouse Cooper Hewitt Co. Ltd., of London is advertising its silica lamp "as a stimulant to egg laying." Is this an incentive to Biddy to "see where she's going," or an attempt to break up the door knob trust?

⁂

Those Why I Work-in a Power-Plant contest postals are coming in rapidly and they're great! You fellows who are holding back had better speed 'er up a bit or you'll never get that five-dollar goldpiece to buy one of those two-quart straw kellys to make a hit in your home village. Come, now, climb down off the cracker barrel (or take your foot off the brass rail) long enough to do yourself proud. The contest will close on June 9. The winner's name will appear in the issue of June 23.

⁂

President Wilson is credited with the admission that there's a slump in business. He says there's no good reason for it; the depression is merely psychological. What are those old things we used to hear about innocuous desuetude, meaningless platitudes and glittering generalities?

⁂

This year's report of the National Lighters (meaning electric) committee on progress is a jimdandy—there's no other word for it. It sways with rhythm, bulges with human interest, and just tangoes with fructification. Of course, it must have been the handiwork of our old friend, T. Commerford Martin. May his days be long in the land!

⁂

As a kid, your Uncle Billy was some keen for history; read all the Rollo books, Deadwood Richard, Prescott, Terman's Boilers (Printer: Don't set this "Broilers"), Creasy's Decisive Battles and Lydia Pinkem, but—when was Abraham Lincoln a past president of the New Jersey State Association? Got a photograph here now showing Lincoln, with Marty Hickey of Jersey City, minus his new three-pint kelly; Jack McMorrin, of Newark, Lonely-Road Inspector Calahan, Passaic Krauss and Home-Run Sears artistically grouped about Old Abe. Is this according to the statoots?

⁂

Sir William Willcocks, the Goethals of the Assuan dam, in Egypt, says that in the East graft is respected rather than despised. Too bad the epidemic ever spread to our shores. It's been dammed by many of our engineers, but something's evidently wrong with the structure somewhere.

⁂

Eleven years ago, Samuel Langley witnessed the failure of his flying machine. The ridicule, the sneers and the insults heaped upon this man of splendid courage and faith broke his heart. Today, Glenn Curtiss, at the request of the Smithsonian Institution, has demonstrated that "Langley's Folly" embodied principles of construction that make successful flight possible—it flew! All honor to Curtiss for his vindication of Professor Langley!

⁂

The pumps in the anthracite mines pump more than 3400 tons a minute, or nearly 1,800,000,000 tons of water a year. If this supply were diverted to those promoters who are selling "gold mines" at 59c. on the hoof—good evening, Ignatz!

⁂

"Professor, we'll have to send this coal down to Georgia and have it weighed," said the student at work on a coal-analysis test.

The professor's batting average on humor was about 0.030. "Certainly not!" he declared. "We have the best balances in the country in our laboratory."

"Well, it's written here plainly enough: 'Coal must be weighed in a dry state.'"

⁂

An English correspondent in "Power User" says the following clipping is the last word in steam-plant management:

SAVED BY A ONE-LEGGED MAN—At a meeting of the Dunmow Guardians, the workhouse master reported that owing to the spring season all the able-bodied men had left and a man of 73, who has a wooden leg and is subject to fits, had been called on as the most active male inmate to take charge of the steam boiler and stoke it ten hours a day.

Evidently, the able-bodied men believed in safety first—and skipped!

Installing the First Exhibit at San Francisco

The first exhibit of the Panama-Pacific International Exposition, a 500 hp Deisel engine manufactured by the Busch-Sulzer Bros Co., of St Louis, was installed in the Palace of Machinery on May 27 with impressive ceremonies, in which state and city officials and executives of the exposition participated. Several hundred guests attended

When Miss Heger, daughter of W. S. Heger, Pacific Coast manager of the Busch-Sulzer Bros. Co., pulled the lever which set in motion the machinery of the giant pile-driver, cheer after cheer rent the air and united with the reverberations from the impact of the steam hammer upon the top of the first pile to be driven in the Palace of Machinery.

Mr. Heger opened the ceremonies by a short address of welcome, and was followed by Capt. Asher Carter Baker, U. S. N. (retired), director of the division of exhibits, who formally accepted the exhibit and presented a deed to Mr. Heger granting the company the right to the central space in the palace.

"We have had many ceremonies here on many various occasions since the day President Taft broke ground for the exposition, but none that was more important than this," said Captain Baker. "There are three phases in the life of an exposition: the construction work, the installation of exhibits and the period during which both the buildings and the exhibits are displayed to the world.

"Today, nine of the principal exhibit palaces are completed and are accepted by the division of works. This marks the near close of the construction period, and the installation of this exhibit at this time, nine months before the opening day, demonstrates the unparalleled progress of the exposition. It is eminently fitting and decidedly appropriate that the first exhibit to be installed should be a Diesel engine, the product of an American manufacturer, and a marvel of mechanical science, which has opened up a new field for the marketing of an important California product, crude oil. It was only recently that the first transoceanic ship equipped with a Diesel engine was launched and on her initial voyage made San Francisco a port of call, loading with California oil."

Lieutenant-Commander Clark Howell Woodward, U. S. N., delivered an interesting talk on the "Use of the Diesel Engine in the Navy." He called attention to the fact that two sister ships are now being built at the Mare Island Navy Yard, the "Maumee," to be equipped with a Diesel engine, and the "Kanawha," with a steam engine, and that this would be an excellent test of the comparative advantages of the two types of engine.

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Annual Convention of National District Heating Association

The sixth annual convention of the National District Heating Association was held at the Hotel Seneca, Rochester, N. Y., on May 26, 27 and 28. It was attended by about 150 members, representing district heating plants of many localities. A notable feature of the convention was the large number of papers presented by men who are actively engaged in district heating engineering, the character of the addresses, papers and discussions signifying that the problems of district installations and operation are being met with a high order of engineering intelligence, skill and perseverance.

The first session was called to order by President S. Morgan Bushnell, Chicago, Ill. In the absence of the mayor the members were welcomed to Rochester by Commissioner of Public Safety Charles E. Owens. A report presented by Secretary-treasurer D. S. Gaskill showed the organization to be in good financial condition. The applications which were favorably acted upon increased the membership to 300.

In his address to the association, President Bushnell commented on the fact that central-station heating was at first regarded as an unwelcome consideration by managers of central light and power stations, who were inclined to avoid the heating problem. It is only within a comparatively few years that there has been an organized effort to collect and systematize information on central steam and hot-water heating projects, to place them on a scientific basis compatible with their economic importance. Figures were quoted showing that it is highly improbable that central steam and hot water systems would be outrivaled by other methods of heat distribution, and especially by electricity, as the cost was about eleven times the cost which has been established for distribution by steam and hot water. Referring to gas as a competitor, the president thought this was a negligible consideration excepting in those districts which are favored by a supply of natural gas. The president also stated that the comfort, convenience, cleanliness and actual economy of central heating are already appreciated by thousands of satisfied customers, and benefiting by the experience of the plants already in existance, it is safe to predict a rapid increase in the number of installations. The statement was made that the capital invested in central station heating now runs into the millions and the number of companies engaged has been estimated at from 300 to 400.

The leading papers and discussions were: Report of Meter Committee; Hot Water Heating Under Forced Circulation; Expense of Operating Centrifugal Pumps, vs. Double Acting Pumps; Some Effects of Utility Regulations as Affecting District Heating; Effect of Superheated Steam on Heating Systems; District Heating for Small Towns and Cities; Heat Losses from Buildings of Latest Construction; Which is More Profitable, to Shut Off Steam at Night or Keep It on Continuously?; Economic Advantages to Consumers of Central Station Heating Service over Individual Heating Plants; Report of Rate Committee; Customers' Steam Heating Systems; Commercial Steam Heating in New York City; Report of Educational Committee; Report of Station Operating Committee.

The officers elected for the coming year follow: President, H. R. Wetherell, of Peoria, Ill., first vice-president, D. S. Boyden, of Boston; second vice-president, B. T. Gifford, of Grand Rapids; third vice-president, G. W. Martin, of New York city; secretary and treasurer, D. L. Gaskill, of Greeneville, Ohio; excutive committee, S. Morgan Bushnell, of Chicago; H. Almert, of Chicago, and C. F. Oehlmann, of Denver.

Professor James D. Hoffman, M. E., past president of A. S. H. and V. E., Mem. A. S. M. E., formerly of Purdue University and now professor of mechanical engineering, University of Nebraska, was elected an honorary member of the association, in recognition of his contributions to the science of district heating

Special entertainment for ladies was provided in auto tours, a trip on Lake Ontario and card parties. A theater party on Wednesday evening and an informal reception on Thursday evening were largely attended by members and guests. On Thursday afternoon a visit of inspection was made to the factory of the Taylor Instrument Co. and on Friday the entire convention, as a guest of the American District Steam Co., went by special Pullman train to Niagara Falls, stopping en route at Lockport, where the first district heating plant was installed. After spending Friday afternoon in sightseeing at Niagara Falls, the members and guests returned to Rochester and the convention was brought to a close.

Power for Steel Mills

SYNOPSIS—There appears to be a wide discrepancy between actual performances and the alleged possibilities of the blast-furnace gas-engine driving alternating-current generators. Some of the deficiencies are pointed out and comparisons are made with a steam-turbine plant.

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Before a joint meeting of the Chicago section of the American Institute of Electrical Engineers and the electrical section of the Western Society of Engineers on April 27, F. G. Gasche, mechanical engineer of the Illinois Steel Co., delivered an interesting lecture on the blast-furnace gas engine as a prime mover for driving alternating-current generators. Due to the discrepancy between actual performances and the alleged possibilities which is now agitating steel mill engineers the subject is timely. It was discussed by Mr. Gasche under the following subdivisions; The laws of thermodynamics, the direct commercial problem and the serviceability of the equipment.

THEORETICAL EFFICIENCIES

Among other things it is known that the limit of thermodynamic efficiency is expressed by the difference of the initial and final temperatures of the working fluid divided by its initial absolute temperature. In the entire domain of prime movers there is available a temperature range of 3000 deg. F., approximately. The conversion of heat into work throughout this range in any one prime mover is physically impossible.

The lower limit of temperature, for average steam-turbine practice, is approximately 80 deg. F. The exhaust from gas engines is rarely under 1000 deg., notwithstanding the enormous water-cooling effect applied to cylinders, ports and valves, but the final temperature of expansion, as the incident of conversion of heat into work by expansive use of the gas, can seldom be less than 1200 deg. F. The limit of thermodynamic efficiency of this type of prime mover, which cannot be approached by a wide margin, is

$$100 \times \frac{3000 - 1200}{3460} = 52 \text{ per cent.}$$

Modern steam turbines of suitable design and capacity may be successfully operated with initial steam temperatures of 700 deg., which with a condenser temperature of 80 deg., gives a maximum thermodynamic efficiency of

$$100 \times \frac{700 - 80}{1160} = 53.5 \text{ per cent.}$$

This cannot be approached on account of practical limitations.

It will be noticed that the temperature range for the gas engine is incapable of material extension without the indulgence of expansions and cylinder dimensions already prohibitive because of mechanical and commercial limitations. Consequently, no material improvement of inherent thermodynamic efficiency is a possibility for the gas engine. On the other hand, there is a wide gap in the temperature range (700 to 1200 deg.) not at present utilizable by any type of prime mover, and which is the exclusive prerogative of the turbine if speculation is made on the tendencies of design.

During the early days of the gas-engine much emphasis was placed on the assertion that with the new type of prime mover no steam boilers would be required. But the enormous jacket-water heat losses were unpopular as a subject of comment. Much stress was laid on the high initial temperatures of working fluid to which the gas engine would be devoted, but no comment on probable high temperatures of exhaust could be indulged. Many dissertations appeared concerning use factor, load factor and efficiency without a suggestion of the hospital records of sick gas engines, and the long periods of convalescence after an exhibition run. Nor was there a suspicion of the disastrous effects on every other prime mover by the injection of the hit-or-miss, impactive, threshing influence on a whole power circuit in the name of an exponent of high thermal efficiency.

ACTUAL PERFORMANCE

In comparing the actual performance of blast-furnace gas engines driving alternating-current generators with the actual performance of turbine-driven units, Mr. Gasche had personal knowledge of the performance of four 2000-kw. gas engines operating for a period of three months with the most favorable conditions for a constant and rated load. Meanwhile, all of the peak loads and variations were assumed by a large turbine in the vicinity. All the fuel gas was measused by a large venturi meter. Statements of the thermodynamic efficiency of larger installations have been uniformly pure fancies of interpretation in the absence of any means for measuring the aggregate gas supply. The coefficient of flow of this venturi meter is known within one per cent. error. Under such circumstances the energy at the switchboard was 19.2 per cent. of the energy supply of the gas.

A recent publication ("Stahl und Eisen," No. 51, 1913) shows an over-all thermal efficiency of boilers, turbine and generators of 13.63 per cent. with long continued service and extremely variable loads. With conditions of load as favorable as that recited for the gas engine plant, the over-all thermal efficiency would be at least 14.5 per cent. On the basis of 19.2 per cent. and 14 per cent. the relative fuel demands of gas engines and turbines for steel mill loads would stand approximately in the ratio of

$$\frac{14}{19.2} = \frac{1}{1.371}$$

that is, the steam turbine would require 37 per cent. more fuel for the same output. Whether this quantity is more or less, a deliberate examination of the contemporaneous performances of different types of plant, or of their relation even ten years ago, will show that the extravagant claims concerning the fuel savings by gas engines were never justified.

The statement was made about the time of the installation of the large gas-engine plants that the turbine would use at least 1½ times the fuel required by the former, and today exponents of gas engines assert that the ratio is at least [illegible] to 1.

INVESTMENT

The direct commercial problem of investment is contemporaneous, since some improvement in both gas engines and steam turbines is to be expected. A promising development of the former consists in the so called scavenging process, being essentially the more complete removal of burnt gases by an injection of air into the gas cylinders previous to the entry of the explosive charge. The rapid advances in the use of high pressures and high superheating of steam is responsible for turbine performances which promise thermal efficiencies fully as high as the best performance of gas engines. Steam boilers and their equipment are receiving a concentration of attention, such that the attainable performances of gas producers will be permanently surpassed.

Attempts have been made to increase the capacity of gas engines by the indulgence of high piston speeds, and thereby decrease the unit cost. The inertia stresses on large gas engines are already high and any movement for their increase in this manner will meet with opposition. Taking the records of the past as some indication of thé prices that may be demanded in the future, and with the additional consideration that the overload capacity of the gas engine is limited to about 25 per cent., the investment situation may be summarized as follows:

A steel mill power plant of gas engines will require such an installation adequate for all peak loads that the cost per kilowatt based on average mill load will be at least $100. Turbine installations for the same character of mill load, and adequate for all peak loads, will cost not more than $55. The relative fixed charges will, therefore, be in the ratio of 55 to 100, or 1 to 1.82. Taking the cost of fuel for the steam turbine plant at $0.003 per kw.-hr., and a 6000-hr. service per year, the fuel cost would be as follows:

Steam turbines	$18.00
Gas engines	15.00

The difference in favor of gas engines is $4.90 per kilowatt per year. Taking the fixed charges of both plants at 15 per cent., the annual charge per kilowatt would be

Steam turbines	$8.25
Gas engines	15.00

The difference in favor of the turbine is $6.75. The advantage of the turbine plant over the gas-engine plant, considering simply fuel demands and fixed charges, amounts to $1.85 per kw. per year. A consideration of operative expense, supplies, etc., will further widen the gap between turbines and blast-furnace gas engines to the advantage of the former.

The iron and steel business has been called the "barometer of trade," with the implication that periods of depression and good times alternate. A power-plant equipment sufficient for the maximum demands of business must of necessity exhibit a number of idle prime movers in periods of depression Leaving aside the reasonable provision of spare units for repairs and maintenance conditions, it is manifest that a type of prime mover requiring a heavy investment constitutes a serious encumbrance to the business during times of depression, because of the heavy fixed charges. A power plant having an additional investment of one million dollars over the requirements of another type of equipment will cause a loss at the rate of $150,000 per year, approximately. Periods of business depression can easily be encumbered with interest losses which, in the aggregate, would buy much of the fuel required by steam equipment during prosperous times.

SERVICE

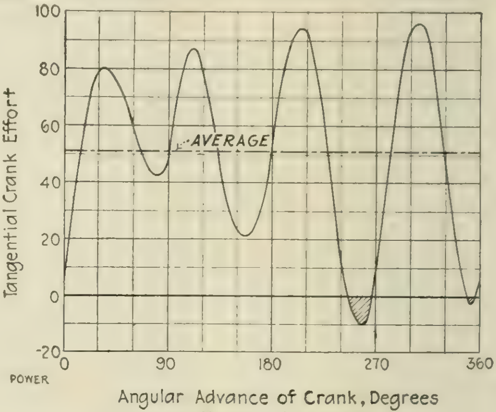
If infatuation for the supposed thermal advantages of the gas engine had not disarmed all discretion, there would not be the array of incongruities now displayed in the attachment of a four-stroke-cycle gas engine, even of the four-cylinder, double-acting type, to an alternating-current generator. This service by all industrial and commercial considerations should give emphasis to uniformity of speed, momentary as well as for average conditions. Take an engine operating at 83 r.p.m., with the four-stroke-cycle action. One stroke in four is effective, and the three preceding, representing a time lag of 2.7 seconds, must attend any attempted readjustment of valve gear to suit a change of load, assuming an instantaneous movement of a governor. The movement of a governor throughout its range can scarcely occur in less than half a second, such that with perfect adjustment and design of the gas engine as a whole it cannot respond to a change of load beyond the small capacity of a flywheel in less than 3 seconds.

It may be considered that the multiplicity of cylinders and cranks giving an impulse twice for each revolution would alleviate this trouble, but reference is made to changes of load, at which time all cylinders are subject to the same time lag due to the four-cycle action. The significance of this time lag will be apparent to the electrical engineer when the character of load imposed on a steel mill power plant is realized. An installation of any magnitude would ostensibly contemplate service to motor driven rolling mills possessing peak load characteristics the severity of which is without precedent or duplication in any other industrial application of electric power. Single operations on a roll train may require energy delivered at a rate of 8000 hp. for three seconds or less. A multiplicity of motor-driven mills may, by nonsynchronous operations, minimize the time and magnitude of peak load requirements on the power plant, but, unfortunately, there is nothing to prevent the superposing of peak loads on the power plant and in very short intervals of time. Under such circumstances, the time lag characteristic of the four-stroke-cycle gas engine renders it incapable of maintenance of reasonable uniformity of speed, and there results disastrous effects on the whole electrical power system. As to providing sufficient flywheel effect on the gas engines, it may be stated that the peak loads in such a plant could be sustained by energy from flywheels for about one second after which additional effort is required of the gas engine and probably beyond the capacity of any practicable number of power units.

CRANK EFFORT DIAGRAM

In crank effort diagrams of steam engines there is more or less deviation from an average value, which is properly provided for in a suitably large flywheel. In the four-stroke-cycle, double-tandem and quarter-crank blast furnace gas engine, operating with a constant load on the generator and with equal and practically perfect gas distribution on both sides of each piston, the crank effort diagram is of the remarkable form here shown.

The ideal crank effort diagram as thus developed is seriously distorted in any actual gas engine of this type because of the inability of the engine to produce such indicator diagrams under "man power" regulation is startling in the absence of any possibility of automatic regulation with change of load. There are four large torque values and two minimum values which are less than zero. In other words, the ideal adjustment of the ideally perfect construction still imposes that twice in each revolution the flywheel must drag the crank and reciprocating parts, and at the same time carry the load on the engine.



CRANK EFFORT DIAGRAM

Flywheels of suitable capacity to accomplish these extraordinary results must be so large that the structures are physically and commercially preposterous, since they cannot be selected alone from consideration of inertia effects. In all cases, prior consideration must be given to the natural and forced frequencies of the gas engine and generator combined, such that the natural periods of oscillation of the wheels do no lead to resonance effects.

The mechanical efficiency of the double tandem gas engine at fractional loads has proved a disappointment, while even for full load it is seldom as high as 85%. The enormous friction loss has a serious effect at fractional loads such that a load factor of 70 per cent. will, in all probability, be attended by an over-all thermal efficiency not exceeding 15 per cent. for the plant.

There is now an opportunity for the optimism with which the engineer should approach such a discouraging outlook. The "legacy" of the gas engine installations is on hand with the one fortunate circumstance that they are not of sufficient capacity for the plants which they serve. Additional equipment of gas engines will not correct inherent defects of the type of prime mover, but a suitable addition of steam turbine equipment will minimize their influence.

In practically every steel plant of the magnitude where gas engines became a habit, there are immense quantities of heat from open hearth furnaces, heating furnaces, etc., which can be effectively applied to steam generation. Delivery of this to steam turbines of a suitable type will favor the production of enough electrical energy to rehabilitate the power-plant service.

DISCUSSION

In the discussion following, all, with two exceptions, were in accord with the author of the paper.

W. B. JACKSON had not had occasion to figure on gas engines of such large capacity, but on units rated at several thousand kilowatts he would recommend a steam plant. In his opinion, the development of the gas engine had been worth while, because it is a deviation from the steam cycle and one step toward the great improvement that must be made in the conversion of heat into electrical energy. The day must come when instead of getting from 3 to 22 per cent. of the energy in the coal, the electrical output will closely approximate the initial energy.

E. W. ALLEN stated that the product of the gas engine did not compare favorably with that of the steam turbine plant. He had looked into the records of a large gas-engine plant and found that the fluctuations from a normal load of 45,000 kilowatts were as high as 15,000 kilowatts. These deviations in load resulted in a change of speed which effected the frequency. Such service might perhaps do for steel mills but not for other plants. Better results would be obtained with the more uniform frequency attained in steam plants. A storage battery would tend to relieve the situation, but the cost of a battery to handle more than 30 per cent. of the load would be excessive.

T. MILTON, a representative of a storage battery company, had observed the operating conditions of a plant having ¼ mile of gas engines and in his opinion the solution of the problem was to put in enough storage batteries to give the gas engine a steady load. Within 3 seconds he had seen a battery swing from 30,000 amperes discharge to 13,000 amperes charge. A battery will care for sudden and heavy changes of load, and if there were enough battery capacity in the plant the change in load could be handled in 1/10 seconds.

O. H. WEST referred to the Gary plant, in which there are 43 gas engines ranging in capacity from 3500 to 4500 kilowatts. The power cost in this station is less than any other plant of the United States Steel Corporation. One of the advantages of the gas engine unit is the rapidity with which it may be started. He had seen them brought up to speed and synchronized on the bus bars in 30 seconds. In operation the regulation has been greatly improved. With the improved governor the speed can be maintained closer than 8 per cent. When a gas engine is thrown from no load to full load and vice-versa.

MR. GASCHE, in reply, admitted that a steady load applied to a gas engine by an alternating-current generator with storage-battery service would be ideal, but no steel plant has a steady load nor can it be prescribed when the peak loads will come. If this were possible, more units could be put on to handle it. With such variable loads from the mill trains on and off so quickly a storage battery would be seriously embarrassed, and unless it had a capacity beyond all reasonable proportions to the load, it would be of little use. As to the time of putting these large gas engines into service, he had seen it done in 1½ min., but the usual time was 2½ min. In reply to a question as to the proper capacity of steam-turbine plant to handle the peak loads of a gas-engine plant, the proportions of 30 and 70 per cent., respectively, were given.

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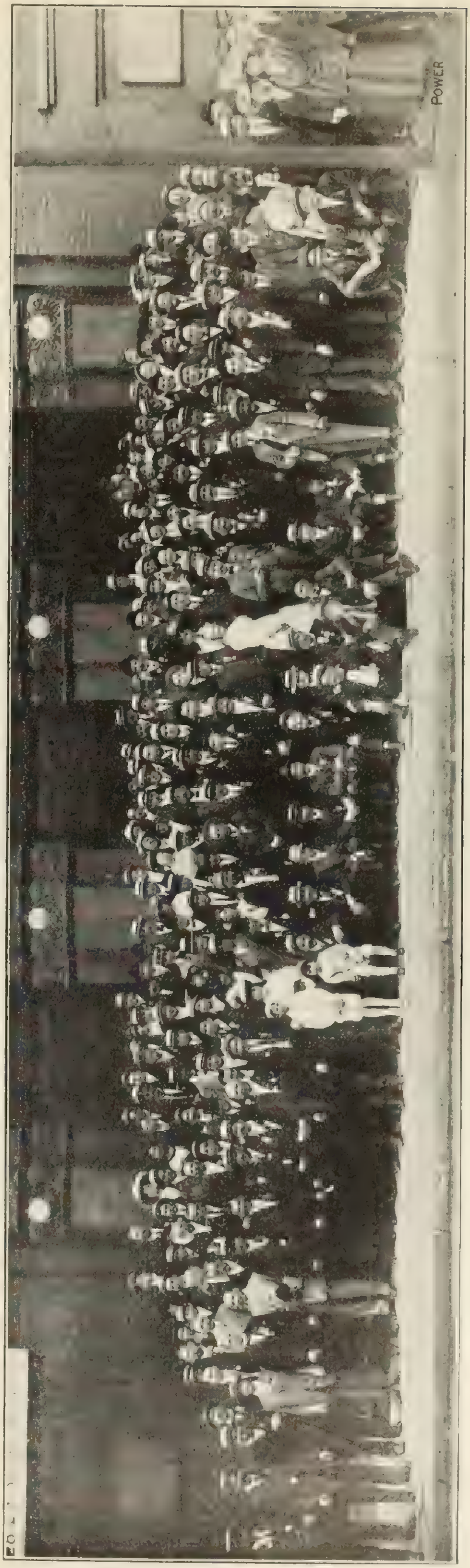
New Jersey N. A. S. E. Convention

From Thursday, May 28, to Sunday, the 30, N. A. S. E. men of New Jersey and the vicinity enjoyed the twenty-third annual convention and exhibit in Elks Hall, Jersey City.

State President Jenkinson called the eleven associations in the state to order for the opening business session at 3:00 p.m. Saturday. At this time the various committees presented



Some of Those in Attendance at the New Jersey N. A. S. E. Convention in Jersey City their reports, most important of which were the reports of the educational and legislative committees. The former committee's report showed most commendable results for the year, although only three fourths of the money appropriation was used. The legislative committee reported that the bureau which will examine candidates and issue licenses under the new state engineers' license law was being prepared for organization by the Commission of Labor.

The beefsteak supper Saturday evening was thoroughly enjoyed by everyone. It is not often that ladies participate in a beefsteak supper, where "fingers before forks" is the rule, but here the fair ones in large white aprons and comic headgear found pleasure.

On Friday evening a smoker, including cabaret talent and refreshments, was given by the exhibitors, who also furnished the refreshments after Saturday's session.

The speakers of the evening were: National President James R. Coe, Assemblyman Griffin, Charles H. Bromley, chairman of the educational committee; Henry D. Cozens, First National President and National Trustees Joseph Carney and William Reynolds. Entertainment was furnished by Jenkins Bros. and Jack Armour of "Power," under the direction of Frank Martin.

On Sunday morning the business was resumed, the following officers being elected: President, Charles Summer, Hoboken; vice-president, Dennis F. Bartley Jersey City; secretary, James S. Heath, Elizabeth, treasurer, Thomas Brown, Newark; conductor, Arthur Truman, Atlantic City; doorkeeper, William T. Brown, Jersey City.

The next convention of the State Association will be held in Trenton in May, 1915.

The exhibits were most commendable, all the booths being well arranged. The exhibitors were:

Republic Flow Meters Co.
Dearborn Chemical Co.
John A. Roeblings Sons Co.
Quaker City Rubber Co.
Charles V. Hoffman
The Philadelphia Grease Mfg. Co.
Standard Regulator Co.
Donegan & Swift
The Fairbanks Co.
Voorhees Rubber Mfg. Co.
A. & F. Brown Co.
Ross & Taggart
Strong, Carlisle & Hammond Co.
The Texas Co.
Garlock Packing Co.
Armstrong Cork & Insulation Co.
Greene, Tweed & Co.
Pitts & Kitts Mfg. & Supply Co.
William Van Keuren
Consolidated Safety Valve Co.
McLeod & Henry Co.
Ladies' Auxiliary of N. J.
Goldschmidt Thermit Co.
Hazard Mfg. Co.
Clipper Belt & Lacer Co.
Gibson Iron Works
A. B. See Electric Elevator Co.
W. B. McVicker Co.
R. & J. Dick, Ltd.
Jenkins Bros.,
"POWER"
Griscom-Russell Co.
Theodore Smith & Sons Co.
Buhne Metal Packing Co.
The Lunkenheimer Co.
Greenpoint Fire Brick Co.
F. W. Webb Mfg. Co.
H. W. Johns-Manville Co.
Cherry Chemical Co.
Smooth-On Mfg. Co.
C. I. Coe Co.
John Simmons Co.
O'Rourke Sheet Metal Co.
Mueller Mfg. Co.
Keystone Lubricating Co.
Albany Lubricating Co.
De La Vergne Machine Co.
Otis Elevator Co.
Homestead Valve Mfg. Co.
Belmont Packing Co.
LeBaron B. Johnson
Peerless Rubber Mfg. Co.
The Richardson-Phenix Co.

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Where Dirt Has Its Use—Don't try to keep the melted babbitt clean, no matter if there is dirt, coal and other refuse on the surface. Let such dirt stay there. Ofttimes it is well to throw in a little dirt of this sort if the metal is clean. This is for the purpose of preventing oxidation of the babbitt. Oxidation causes a lot of dross to form and uses up a corresponding weight of babbitt. Covering the top of the babbitt pot to keep the air from the hot metal will prevent considerable of the dross forming.—"Gas Review."

Master Boiler Makers' Eighth Annual Convention

The eighth annual convention of the Master Boiler Makers' Association and the Boiler Makers' Supply Men's Association was held in Philadelphia, Penn., May 25 to 28, inclusive, with headquarters at the Hotel Walton; the convention hall was on the tenth floor.

The convention was called to order at 2:30 p.m., on Monday, the first day, and after the invocation by Bishop Joseph F. Berry, addresses were made by Mayor Blankenburg, S. M. Vauclain, vice-president and general manager of the Baldwin Locomotive Works, and Ivy D. Lee, chief executive assistant to the president of the Pennsylvania R.R. Responses were made by M. O'Connor, past president, C. P. Patrick, fifth vice-president, and G. W. Bennett, past president. These were followed by the president of the association, T. W. Lowe, with his annual address. The rest of the session was given up to reports and miscellaneous business. During the afternoon a joint meeting of the Supplymen's Association and the Philadelphia committee of arrangements was held. In the evening the eighth annual reunion, reception and dance was held in the ballroom of the hotel.

The second day's session was devoted to addresses by S. G. Thompson, superintendent of motive power and railway equipment of the Philadelphia & Reading R.R., and Frank McManamy, chief boiler inspector, Interstate Commerce Commission. Mr. McManamy urged that a closer cooperation and more amiable relations between the officials and inspectors of the Interstate Commerce Commission and the manufacturers of steam boilers be brought about, so that a more intelligent understanding of the requirements of the Federal law might obtain, which would reduce the fatalities and casualties due to faulty boiler construction.

GROUP OF MASTER BOILER MAKERS, SUPPLY MEN AND GUESTS ON THE LAWN OF THE RESIDEN

The trend of the speakers in discussing the question was to the effect that boiler makers should change their attitude toward the Federal inspectors and to either obey the Government inspection law and the orders of the commission, or present to the Government good reasons for not doing so.

Mr. McManamy emphasized the fact that the interests of the railroads, the manufacturer and the Government officials are common, and that they are all working for increased efficiency in serving the public. No law for safeguarding life, said the speaker, had been so successful as the present inspection law, which during the first year of its enforcement decreased the loss of life 60 per cent. on railroads, and in the last nine months compared with the nine months of last year the reduction has been 48 per cent.

Then followed the committee's reports on the following subjects:

"What Are the Advantages or Disadvantages of Using Oxyacetylene and Electric Processes for Boiler Maintenance and Repairs?"

"What Benefit Has Been Derived from Treating Feed Water for Locomotive Boilers Chemically, etc.?"

"What Can the Association Do to Get a Uniform Rule Regarding the Load Allowed on Staybolts and Boiler Braces?"

"The Advantage or Disadvantage of Combustion Chambers in Large Mallet or Pacific Type Engines Other than a Shorter Flue."

In the afternoon the committee reported on the following:

"What Shape and Size Head of a Radial Staybolt in the

Crown Sheet of Oil Burning Engines Gives the Most Efficient Service?"

"Does the Method of Flue Cleansing or Rattling Have Any Effect on the Further Scaling up of Flues?"

"Combustion and Fuel Economy."

"The Proper Inspection of a Boiler while in Service."

While the convention was in session, an automobile trip and luncheon were given to the ladies. In the evening a theater party was held at Keith's Theater.

All business was suspended on Wednesday, the third day of the convention, to accept the invitation extended to the members of the convention and Supplymen's Association, and to their ladies and guests to visit the plants of the Parkesburg Iron Co., Parkesburg, Penn., and the Lukens Iron & Steel Co., Coatesville, Penn. About 500 persons made the trip in a special train. Lunch was served in a large tent on the lawn at the residence of A. F. Huston, president of the Lukens Co. An address of welcome was delivered by Mr. Huston, to which T. W. Lowe, president of the Master Boilermakers' Association, responded. After inspecting the plant the party left on the return trip at 5:30 p.m.

In the evening there was an entertainment consisting of vaudeville and a lecture, illustrated by motion pictures, on Panama, by Frederick Poole.

The session of the fourth and last day was opened by an address by Henry T. Hartley, past president of the American Boiler Manufacturers' Association and superintendent of the boiler department of the William Cramp & Sons Ship & Engine Building Co. He contrasted modern boiler construction with that of several decades ago and pointed out the improvement and advancement in the construction of steam boilers.

The election of officers for the ensuing year concluded the convention, at about one o'clock. They are as follows: James T. Johnston, Los Angeles, Calif., president; Andrew Greene, Indianapolis, Ind., first vice-president; D. A. Lucas, Havelock, Neb., second vice-president; John B. Tate, Altoona, Penn., third vice-president; Charles T. Patrick, Cleveland, Ohio, fourth vice-president, and Thomas Lewis, Sayre, Penn., fifth vice-president. Harry D. Vought, of New York, was reëlected secretary, and Frank Gray, of Bloomington, Ill., reëlected treasurer. The members elected to the executive board were Harry Winterstein, Harry Weldin and Thomas T. Powers.

Secretary Vought reported that 48 new applications had been made for membership during the convention, and that 23 members had been received into the association since the last annual convention, a gain for the year of 71 in new members.

Thursday afternoon was given over to an automobile trip for the ladies to points of interest, and to a visit to the Baldwin locomotive works by the members and guests of both associations. The trip was made in automobiles to the works, where an interesting afternoon was spent. A banquet was tendered to the Master Boiler Makers' Association by the Supply Men in the banquet hall of the hotel as a fitting closing of a successful gathering in convention of boiler makers from various parts of the United States and Canada.

⁂

The Largest Pumping Station—It is stated that the pumping station for the Jefferson and Plaquemines Drainage District in Louisiana will be the largest in the world, having an ultimate capacity of 900,000,000 gal. in 24 hours. There will be installed four 76-in. pumps of 192,000,000 gal. capacity each and two 48-in. pumps of 64,000,000 gal. each per day.

Recent Court Decisions

Digested by A. L. H. STREET

Service Rates in Arizona—The law enacted at the 1912 special session of the Arizona Legislature requiring electric companies to afford service on the meter basis, was lately held by the state supreme court to be invalid, as violating the provision of the Arizona constitution which vests power in the Public Service Commission to fix rates for such service. (State vs. Tucson Gas, Electric Light & Power Co., 138 "Pacific Reporter," 781.)

Cancellation of Patents to Public Lands—Patents granted by the United States covering public lands entered as mining claims are subject to cancellation on proof that the lands were actually entered on account of water power thereon, and not for mining purposes, according to the decision of the United States Circuit Court of Appeals, Ninth Circuit, in the recent case of Multnomah Mining, Milling & Development Co. vs. United States, 211 "Federal Reporter."

West Virginia Public Service Commission—The scope of the powers of the West Virginia Public Service Commission was lately the subject of consideration before the supreme court of the state, in the case of United Fuel Gas Co. vs. Public Service Commission, 80 "Southeastern Reporter," 931. It was decided that, although the supreme court of appeals has jurisdiction to review an order adopted by the commission, in an original proceeding brought for that purpose, no order may be disturbed unless it appears to be beyond the statutory or constitutional powers of the commission, or that it was based upon a mistake of law made by that body. An order based upon what the commission deems to be best for the public interests is final and not reviewable by the courts. The supreme court of appeals will not disturb an order prohibiting discrimination in fuel gas rates based solely upon the question of whether the consumer has contracted to take service for a period of five years or is not committed to take it for any definite time.

Warranty of Power Plants—Two important legal principles applicable to sales of power machinery were involved in the case of the General Electric Co. vs. Alderson, 210 "Federal Reporter," 775, recently passed upon by the United States Circuit Court of Appeals for the Fourth Circuit. One point is that the plaintiff, in contracting to manufacture and install in a building at Charleston, W. Va., a power and lighting plant, in accordance with definite specifications, did not impliedly warrant that the plant was adapted to the particular building. The other point is that, where a contract to sell machinery contains express warranties concerning it, the parties will be presumed to have expressly stipulated all the warranties that were intended to be made and none will exist by implication. Incidentally, the court concludes in the same case that a warranty "that the turbine and generator connected therewith will run continuously at its normal rated capacity without undue heating, undue noise or vibration," relates only to the performance or behavior of the particular machinery as such, and not to the effect of its operation upon the building in which it was placed.

OF A. F. HUSTON, PRESIDENT OF THE LUKENS IRON & STEEL CO., COATESVILLE, PENN.

Two Serious Explosions at Detroit

On May 9, two men were fatally injured by the explosion of a boiler at New Baltimore, Mich., at the Detroit United Ry. (Shore Line) power house.

The boiler in question is a Babcock & Wilcox horizontal water tube, and is rated at 300 hp., having nine horizontal rows of 16 tubes, each 4 in. in diameter.

A new steel mud drum $\frac{5}{8}$ in. thick, having an internal cross-section of 6x6 in., was recently installed, taking the place of a cast-iron mud drum. This was attached to the serpentine headers at the rear by sixteen 1-in. extra-heavy nipples, $4\frac{1}{4}$ in. long. Fifteen of these nipples were firmly retained in the headers of the boiler and one in the new mud drum. The tube holes in the new header were fairly uniform in size, but tapered, being $\frac{1}{8}$ in. larger at the outside of the hole. This was probably the prime factor in causing the failure.

It is evident that, in machining the tube holes, a cutter was used that had worn somewhat tapered. This condition would make it difficult to expand the tubes so as to make the job safe and secure. The boiler otherwise was in first-class condition, and the gereral maintenance of the plant was excellent.

On May 13, one life was lost in the plant of the Detroit Copper & Brass Co. One of the front tubes of a Wickes boiler became obstructed by pieces of scale, which blocked the tube about $1\frac{1}{2}$ ft. above the lower drum, and when the water evaporated, the tube fused and the contents of the boiler were discharged into the dutch oven furnace, having a Murphy stoker. The front tubes were overheated and their elongation put a severe stress on the tube sheet, the stay-rod construction being rigid the stress caused the failure of more than half of the crow feet in both drums, breaking them at the bends and dishing the tube sheet top and bottom about $\frac{1}{4}$ in. The row of tubes in front of the furnace was pushed through the tube sheet about $\frac{1}{4}$ in., and one tube was found to be entirely pulled out of the lower tube sheet upon cooling the boiler.

It will thus be seen what heavy stresses can be caused by long tubes and rigid construction. A similar accident would not have occurred under the same circumstances had the present construction of the Wickes company been used, which provides for a minimum section of stays throughout the major part.

ENGINEERING AFFAIRS

The National Association of Corporation Schools will hold its second convention in Philadelphia, June 9, 10, 11 and 12. The association was organized in New York, Jan. 24, 1913, "to aid corporations in the education of their employees, (1) by providing a forum for the interchange of ideas and (2) by collecting, and making available, data as to successful and unsuccessful plans in educating employees." Arthur Williams, New York Edison Co., is president. The membership approaches 150 in all classes, covering 32 different industries.

Preparing for the Boiler Manufacturers' Convention—The Supply Men's Association of the American Boiler Manufacturers' Association, which has in charge the social features of the program for the convention to be held in New York City, Sept. 1 to 4, has the plans for it pretty well worked out. Two meetings have been held in New York and an executive session in Philadelphia to arrange for the program and the financing of the entertainment. At a meeting June 2 in the Waldorf-Astoria, Chairman Thomas Aldcorn, Secretary T. B Slocum and Treasurer D. J. Champion reported on the work already done and a tentative program was adopted.

The Seventh Annual Picnic and Field Day of the combined associations of the N. A. S. E., of Brooklyn, N. Y., took place at Juniper Park, Maspeth, L. I., on Sunday, May 31. The associations comprising the combination are the Modern Science Club, Brooklyn Council No. 8, U. C. C. of E., Melville Council No. 9, U. C. C. of E., Brooklyn Association No. 8, N. A. S. E., Brooklyn Association No. 27, N. A. S. E., Brooklyn Association No. 41, N. A. S. E., Brooklyn Association No. 57, N. A. S. E. Outdoor sports of various kinds were indulged in, with appropriate prizes to the winners. A feature of the event was the baseball game between the Robert Gair Club and the "Bunch," which resulted in a victory to the former by the score of 10 to 6. Dancing brought to a close a very enjoyable day.

Connecticut N. A. S. E. Convention—The annual state convention of the Connecticut N. A. S. E. will be held in Bridgeport, on June 26 and 27 in Eagles Hall, Madison Ave. The exhibition this year will be on a larger scale than that held two years ago, when Colonial Hall was taxed to its capacity.

The interest shown by the supply houses and the supply men's association in the coming convention and exhibition made it necessary for the committee in charge to engage the entire floor space of Eagles Hall. The expense is borne by the engineers and supply men, consequently the exhibition should be one of the finest and largest exhibitions of power plant and engine supplies ever produced in the state. The general committee of arrangement is as follows: F. J. Quinlan, chairman, Edward S. Burge, C. D. Osborn, W. Goodrick, P. J. Grace, Jos. Bellwood, A. McNiel, Jr., F. Anderson, F. S. Buckley, N. S. Beushan, E. J. Grace, C. M. Dowd.

International Engineering Congress—The general subjects to be treated before this body at San Francisco, Sept. 20 to 25, 1915, will include these topics: Timber; Preservative Treatment of Timber; Substitutes for Timber in Engineering Construction; Brick in Engineering Structures; Clay Products in Engineering Structures; Probable and Presumptive Life of Concrete Structures Made from Modern Cements; Aggregates for Concrete; Slag Cement; Waterproof Concrete; Cements Containing Additions of Finely Ground Foreign Material; Economics of the World's Supply of Iron; The Life of Iron and Steel Structures; The Employment of Special Steel in Engineering Construction; The Place of Copper in the Present Engineering Field, and the Economics of the World's Supply Thereof; Alloys and Their Use in Engineering Construction; Aluminum in Engineering Construction; The Influence of the Testing of Materials upon Advances in the Designing of Engineering Structures and Machines; Cement Testing; Testing of Metals; Testing Full-Sized Members; Proof Testing of Structures.

The papers to be presented from the United States have already been arranged for from the recognized leading authorities on the various topics. Arrangements for the papers from foreign authors are being rapidly concluded, and the aggregation of papers which will be presented will constitute a broad review of the field and be of the highest value. Marked interest in the congress from foreign countries continues, and there is every evidence that the attendance from abroad will be large. It is hoped that all engineers in this country who have not yet subscribed as members of the congress will give the matter their immediate attention and favorable action. Full information concerning the congress may be obtained by addressing the International Engineering Congress, 1915, Foxcroft Building, San Francisco, Calif.

PERSONALS

F. N. Kollock, Jr., of the Westinghouse Electric & Manufacturing Co., has resigned his position as district manager of the Seattle office to accept the position of treasurer and assistant secretary of the Westinghouse Lamp Co., Bloomfield, N. J. W. D. McDonald, formerly branch manager of the Minneapolis office, has been appointed to succeed Mr. Kollock as district manager at Seattle, and C. C. Curry is acting branch manager at Minneapolis, succeeding Mr. McDonald.

OBITUARY

JOSEPH W. SWAN

Sir Joseph Wilson Swan, the inventor of the incandescent electric light and of the rapid dry plate, used in photography, died on May 27. He was 85 years old. Sir Joseph was born in Sunderland on Oct. 31, 1828. He served an apprenticeship with a chemist in Sunderland and became a member in a manufacturing chemists' firm in Newcastle. The firm made photographic plates and Swan's experience resulted in the first rapid dry plate and in the first commercially practicable process for carbon printing in photography.

He was one of the first to attempt the construction of an electric lamp using a filament of carbon. His first lamp of this kind was made in 1860, the filament being of carbonized paper. Thomas A. Edison adopted a similar method nearly twenty years later. Sir Joseph also conducted experiments and developed new methods in connection with the measurement of electric currents and improved accumulators.

He was elected a fellow of the Royal Society in 1894 and was knighted in 1904.

POWER

Vol. 39 NEW YORK, JUNE 16, 1914 No. 24

The Engineer's Future

The operating engineer is constantly faced with the admonition "Learn more to earn more." Looking at matters from the engineer's standpoint, we might well ask the question "What shall we learn?" The adviser promptly answers "More about your work as an engineer." We then answer "Our knowledge of engineering has increased, as is proved by the list of plants from which we hold endorsements showing that we have competently operated different types of engines, many types of boilers and electric equipments. We are now in charge of the same work that we took hold of at the beginning, only in larger proportion—in a larger plant, but still responsible for the operation. We are confined to exacting hours of duty—expected to give attention to extra work at all times if necessity requires it—usually without extra pay. Vacations are not known because there must be no loss of time due to an inoperative plant.

"Our progress is represented only in the difference in the amount of responsibility. Therefore, 'What shall we learn?' "

When we first enter as the oiler or fireman in the power plant our constant aim is the higher position occupied by our superiors. When we ultimately reach this position, are we then to stop and be content?—But the preceptor answers "Learn more." The public, therefore, puts itself in a very peculiar position. It lays down advice for the operating engineer, but utterly fails to clarify the situation, so that the engineer may intelligently be benefited. No one would suggest to the engineer that his studies be along different lines, such as languages or chemistry. We must then ask ourselves is there any truth in the public's statement, and if so, where does it apply? To this point I will attempt an answer:

If the engineer is in a place wherein he is congenially situated, would it not be logical for him to pay specific and careful attention to the details of the business for which he is daily producing power, and thus be in a position to not only protect power production but to co-operate with its actual management and thus prove himself capable of handling more than one special line of work? An engineer who has already established by service that he is capable and to be depended upon should be able to build on such a platform a further step of progress by learning the details of the business, and there are many plants where it is has been my pleasure to find that as the years progressed the engineer progressed, ultimately leaving the details of his engine room to men whom he could rely upon under his general direction, whereas he became the superintendent of the whole plant and thus had reached the goal wherein he could secure for himself the time to take a vacation by having organized the departments under capable subordinates who could carry the details for a period during his absence, and enable him to enjoy the results which hard work should have wrought.

Another line of study: Let the engineer become so conversant with the details of the equipment that he is operating that he is an authority as to its efficiency. His opening then is to work for the manufacturer of those particular machines, be they engines, motors or any kind of operating machinery, and by his knowledge secure that remuneration so long sought for. I think both of these outlets are the two logical broad avenues over which an engineer should ultimately hope to travel, selecting the one to which he is most adapted. Those of us who have had the pleasure of dealing with the engineering salesman who thoroughly knew the subject which he was representing—who could tell us clearly and quickly the things we wished to know, and which we would be most likely to ask, without making us do the cross-examining—have placed our confidence with the man who knew. Who should be better qualified to know than a man who has had the training with the actual operation of machinery?

Engineering salesmen should be capable operating engineers in these days of modern economy. Who should be more competent to keep down operating costs or ably represent operating equipment than the man who not only knows every detail of manufacture, but understands all the details of the power plant and its requirements?

[*Written by Charles H. Parsons, New York City.*]

Reid, Murdoch's New Plant

By Thomas Wilson

SYNOPSIS—A 400-kw. electrical plant supplying exhaust steam for heating and refrigeration. In average winter weather the supply and demand for exhaust steam balance, and in summer there is not enough exhaust steam in excess to warrant a condensing installation.

⁂

One of the most convenient and uptodate buildings for the wholesale-grocery trade has just been erected by Reid, Murdoch & Co., of Chicago. It has a river frontage of 325 ft. and the main portion extends back 200 ft. to North Water St. East and west the building is bounded by Clark and La Salle Sts. With its nine stories of brown brick and a tower containing clocks with 15-ft. dials, it is attractive, and might well serve as an example to others who wish to conform to Chicago's latest slogan, "Beautify the river."

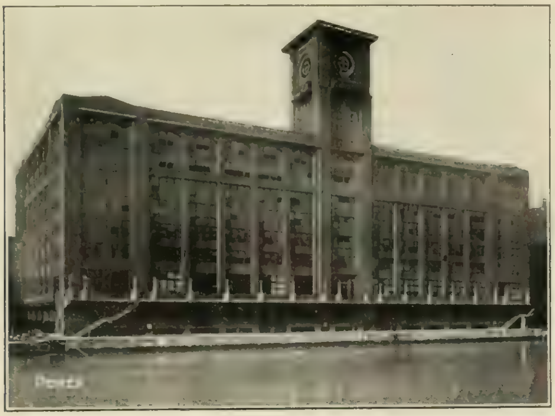


Fig. 1. Reid, Murdoch's New Warehouse

For shipping and receiving, the building has both water and rail facilities. The sub-basement is somewhat below the dock level and the basement is above at the level of a freight-car floor, with the cars at the North Water St. grade. All shipping is done from the basement. Two railroad tracks occupy the north portion, the entire west face is given over to wagon shipments, and the south side to transportation by water.

For handling freight there are four electric elevators of the winding-drum type, with provision for a fifth, and one traction passenger machine, with room provided for a second. Motors of 40 and 30 hp., respectively, with the accompanying apparatus were installed in penthouses over the shafts by the Pitt Engineering Co. In addition to the elevators, there are one double- and one single-spiral chute extending the full height of the building and a power conveyor with a system of secondary gravity conveyors designed to receive freight in carlots and deliver it to various locations on the warehouse floors without handling any package from the time it is lifted in the car.

Although the building is mainly warehouse, on the upper floors there is some machinery, including a complete coffee-roasting plant, labeling and dried-fruit rooms, baking-powder department, etc. All of the machinery is operated electrically, and in general Crocker-Wheeler motors are used. There are about 40, these for the most part being 5- and 10-hp. machines with a few 15-hp. motors on the large ventilating fans. For illumination, the electrical installation is unusually complete, including direct lighting for the entire warehouse and indirect lighting in the offices. The stairs, halls and fire escapes are from independent circuits which may be controlled from the engine room. For heating, 30,000 sq.ft. of direct radiation has been installed and for ventilation 3000 sq.ft. of "Vento" radiation in connection with the fans which, in effect, is equivalent to 9000 sq.ft. of direct surface. There is also a 40-ton Carbondale absorption refrigerating plant, although the present requirements will not call for much more than three-quarters of the rated capacity.

To fulfill these various demands an uptodate private plant was installed. Five hundred horsepower in boilers serve two 200-kw. generating units made up of a 17x22-in. Ball four-valve engine connected directly to a Crocker-Wheeler three-wire, 110-220-volt generator running at 200 r.p.m. Exhaust steam from these engines is supplied to the heating system and to the absorption refrigerating plant. Although the plant is on the river, a condenser was not provided, as there is little exhaust steam in excess of the heating and refrigerating demands.

During April the load on the generating units averaged 1600 to 1800 kw.-hr. per day of 11 hr. With a uniform load this would call for a generator capacity of 164 kw., but fluctuations gave peaks of over 200 kw. In the winter months the load will probably exceed the April demand, and run close to 200 kw., or 24,200 kw.-hr. per day. The guarantee on the engine was 22 lb. per indicated horsepower-hour, so that in operation the rate should average about 35 lb. per kw.-hr. On the maximum winter load there would be available per hour

$$200 \times 35 = 7000 \text{ } lb.$$

of exhaust steam, whereas in zero weather the heating and ventilating systems would require

$$(30{,}000 + 9000) \times 0.3 = 11{,}700 \text{ } lb.$$

There are only a few days of zero weather during the season, so that but little live steam will be required for heating except at night, when the engines are not running. Ordinarily, the heating demand will not be much more than half of the above figure, and there will be plenty of exhaust steam in addition to furnish whatever refrigeration is needed during the heating season. In the five warmer months the refrigeration will run about 30 tons. With cooling water at 70 deg. F. and exhaust steam at ½ lb. pressure, each ton will require 35 lb. of steam, or a total of 1050 lb. per hour. The electrical load will probably be somewhat lighter than in April and it may not exceed 150 kw. With a uniform load, there would be available about

$$150 \times 35 = 5250 \text{ } lb.$$

of exhaust steam per hour from the main units to help the auxiliaries supply the refrigerating system and to heat the water for boiler feed and house purposes. Not more than 3000 lb. per hour would be exhausted to atmosphere, and for 130 days of 11 hr. the total would be

4,290,000 lb. At 20c. per 1000 lb., this quantity might be valued at $858.

A condenser in an installation of this size would not increase the efficiency more than 20 per cent., so that the annual saving thus effected would not exceed $171, which would limit the investment to $1368, figuring 12½ per cent. for interest and depreciation. If the refrigerating load increases to rating, as is expected in time, or if steam is produced for less than 20c., the margin would be still smaller, so that a condenser would not save enough to pay the usual interest and depreciation on the investment, not to mention the complication of the piping and the additional equipment that would be needed With a condenser it would be necessary at times to use live steam for the refrigerating plant; this would tend to counteract any advantage from the former.

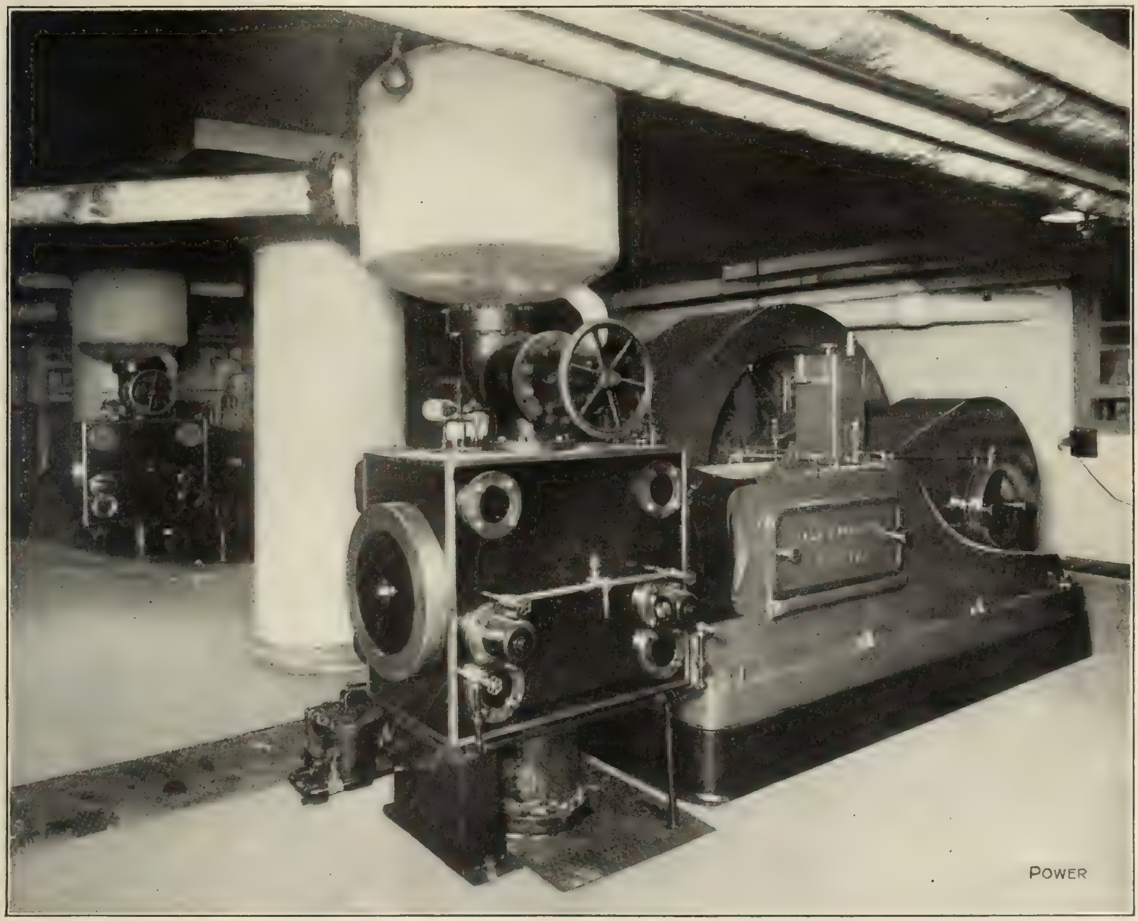


Fig. 2. The 200-Kw. Generating Units

Boiler Room

There are two boilers and provision is made for a third, of the B. & W. steel-header type, horizontally baffled, and each containing 2500 sq.ft. of heating surface. They are equipped with Green chain grates, 5 ft. wide and 9 ft. long, having an effective area of 42.9 sq.ft. A lined, steel breeching with a uniform section of 4½x6 ft. serves the two boilers; the lined steel stack rises 165 ft. above the boiler-room floor, and 30 in. less above the grates. It is 5 ft. in diameter and on the stack side of the damper produces a draft of 0.87 in. of water. Over the fire the draft reduces to 0.4 in. The ratio of heating to effective grate surface is 58 to 1. The sectional area of the breeching bears a ratio to the connected grate surface of 1 to 3.18, and to the stack area a ratio of 1 to 0.73. For every square foot of sectional area in the stack there is 4.37 sq.ft. of grate.

The working pressure is 125 lb. gage, although the safety valve is set to pop at 140 lb. Each boiler is equipped with Vulcan soot cleaners. The usual dusting doors have been omitted and the entire boiler setting has been made air-tight by means of 2-in. "Vitrobestos" covering outside of the brickwork.

One feature is a system of galleries. On the main gallery is a Cochrane open heater with a recording V-notch meter. On the front of the boilers is mounted a washout gallery from which the front-tube caps are accessible. The gallery structure also supports the stoker shaft, which is belt driven by either a motor or a small vertical engine mounted on the main gallery. The main header, which is 6 in. in diameter, is approximately 4 ft. from the ceiling, and is accessible from an upper gallery so arranged that all important valves are within reach.

Another feature is an Eclipse smoke indicator designed by T. W. McNeill, chief engineer of the plant. It has an incandescent lamp with an X-ray reflector mounted in a sleeve on the rear side of the breeching. The light shines through the breeching and a glass-faced sleeve mounted opposite a sight box visible from the front of the boilers. In this box the light strikes a 45-deg. mirror and is reflected at right angles onto a ground-glass screen. When smoke passes through the breeching it cuts off the light, and the density of the smoke may be gaged by the color of the screen. With no smoke it is white, with dense smoke it is black, and with various densities of smoke the screen is shaded accordingly. It is thus possible for the fireman to observe the immediate effect of his work, and by continued observation he can learn how to avoid making smoke.

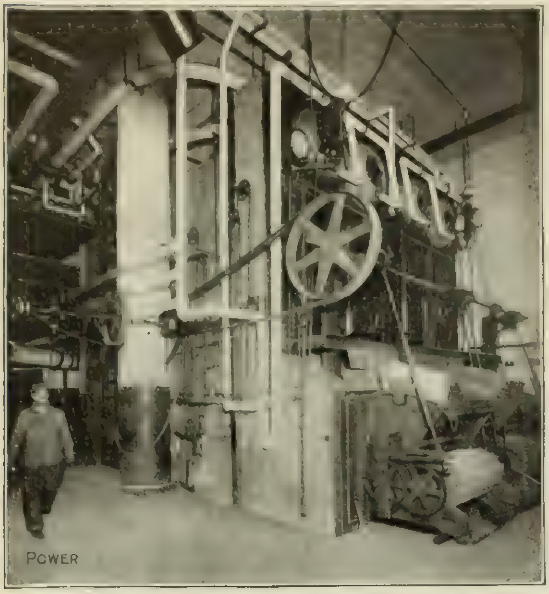


Fig. 3. Boiler-Room Equipment

In front of the boilers there is storage for 150 tons of coal, which is received from the railroad cars above and, after being weighed, is shoveled into the stokers. The ashes are discharged directly from the ashpits into a shaft leading to the Illinois tunnel, which is Chicago's underground subway for handling freight. Water for feed purposes comes from the heating system in winter and the makeup from the city mains. At 210 deg. it flows from the heater to either one of two 8 and 5 by 12-in. Warren pumps and is forced to the boilers. A venturi meter measures the supply and checks the results obtained by the Lea recorder in the heater; the pumps are piped to supply the 60,000-gal. tank of the sprinkler system in the tower. The pumps are at one end of the engine room, where are grouped an Alberger 3-in. turbine-driven house pump, an Alberger 3-in. brine pump, a Warren 7½x10-in. direct-acting brine pump, a Westinghouse air pump for the sprinkler system and two American 8 and 12 by 12-in. vacuum pumps used on the heating system.

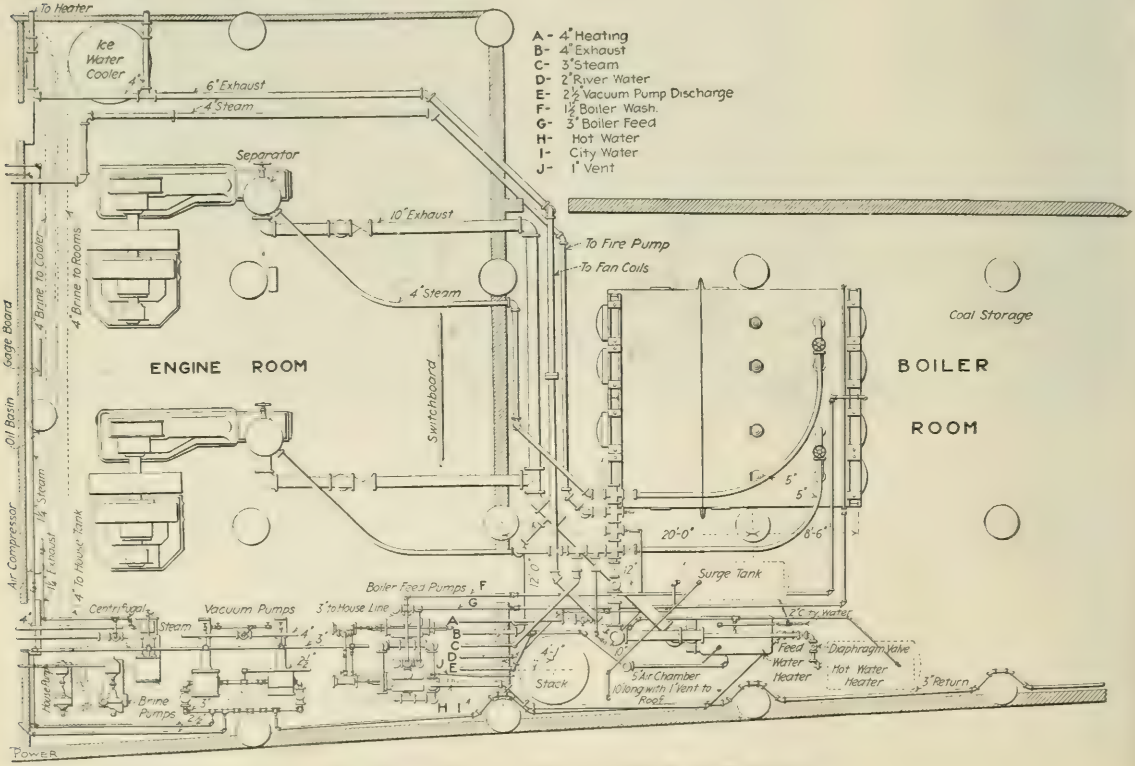


Fig. 4. Layout of Boiler and Engine Rooms

The size of the generating units has been previously given as 200-kw. Each engine is supplied with steam by a 4-in. pipe which leads into a large separator drained to the heater. This diameter gives a sectional area of 0.0636 sq.in. per kilowatt of rating and an average velocity for the steam of 4200 ft. per min. The exhaust pipe, which is 10 in. in diameter, has on the same basis 0.3943 sq.in. and an average velocity of 5700 ft. The two exhausts unite into a common 12-in. pipe running to the oil separator of the heater. From this point a 10-in pipe supplies the heating system and a 4-in. tap from it feeds the hot-water tank. Provision is also made to supply the heating system with live steam, and a 4-in. branch tapped from the 12-in. exhaust pipe supplies the refrigerating system with steam. This pipe is also fed with the exhaust from the steam pumps.

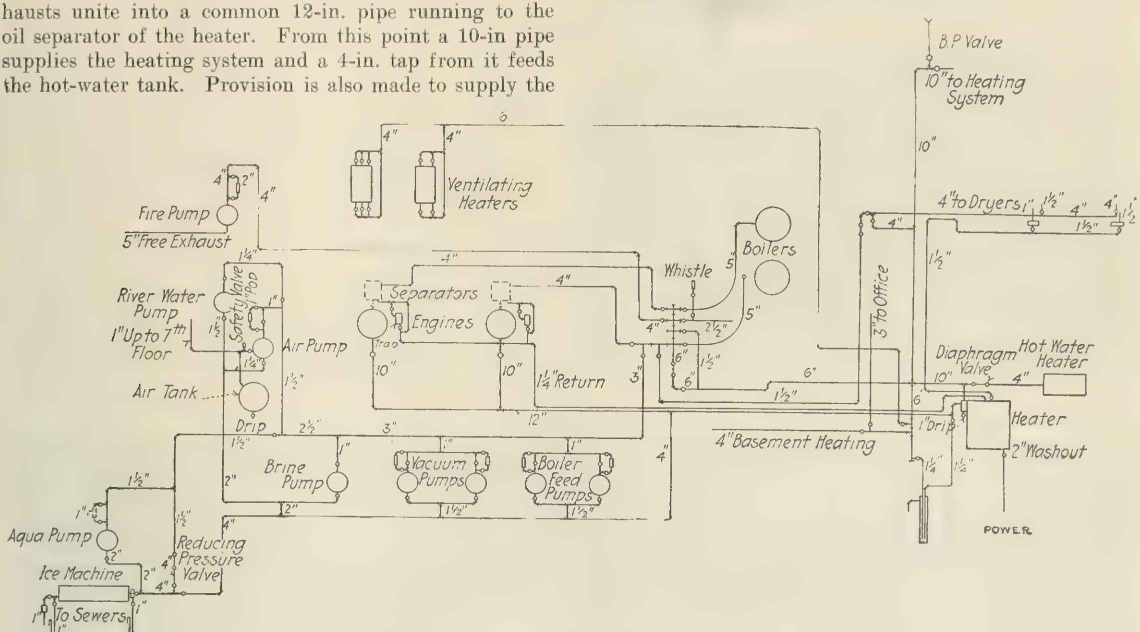


Fig. 5. Piping Connections of the Plant

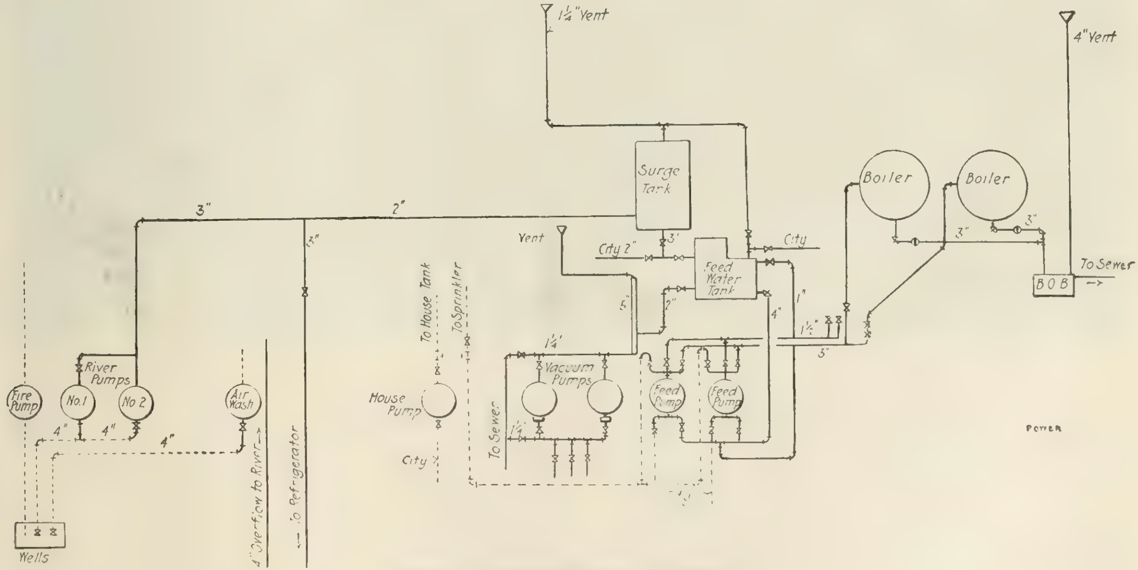


Fig. 6. Water-Piping Diagram

The switchboard, which has five panels, is equipped with Weston ammeters and voltmeters and four Duncan watt-hour meters, one for power, one for the lighting, one for the elevators, and a totaling meter which records the output. For the motors the voltage is 220 and for the lights 110. For emergency night lighting there is an Edison throw-over switch.

A gage board in the engine room is well supplied with instruments to indicate the various pressures in the plant. There are gages for high-pressure steam, city water, river water, sprinkler system, brine and air; combination pressure-vacuum gages for the heating system and house returns; combination pressure and temperature gages for the generator and cooler of the refrigerating system, a gage to indicate the head in the house tank, a recording steam-pressure gage and an eight-day clock.

HEATING AND VENTILATION

To heat the building in zero weather requires 30,000 sq.ft. of direct radiation, which in general is in radiators hung on the walls and supplied from down-feed piping: each radiator is equipped with Illinois vacuum valves. The returns are run to the vacuum pumps and by them are fed to the Cochrane heater. On the first floor, which is mainly offices and salesrooms, the direct radiation is supplemented by a ventilating system. A shaft from the roof to the sub-basement furnishes the supply of fresh air. The air is led into the fan room adjoining the engine room where it encounters a set of heating coils, a Webster air washer and a set of reheating coils; this washer is equipped with sheet-zinc eliminator plates to prevent corrosion.

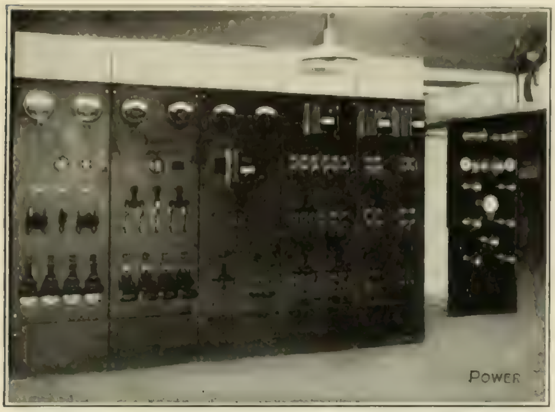


FIG. 7. SWITCHBOARD AND GAGE PANEL

Provision has been made for humidity control, and it is intended to supply the air at 90 deg. in winter with the humidity averaging close to 65 per cent. Two motor-driven fans handle the treated air; one 60 in. in diameter supplies 30,000 cu.ft. per min. to the offices. This is based on about six air changes per hour. The smaller fan supplies 10,000 cu.ft. from the humidifier without reheating to the engine and boiler rooms in the sub-basement. Foul air from the offices is collected in a second system of ducts and is discharged at the second floor by the main exhaust fan, which is in the sub-basement. With this system in operation the office floor is independent of

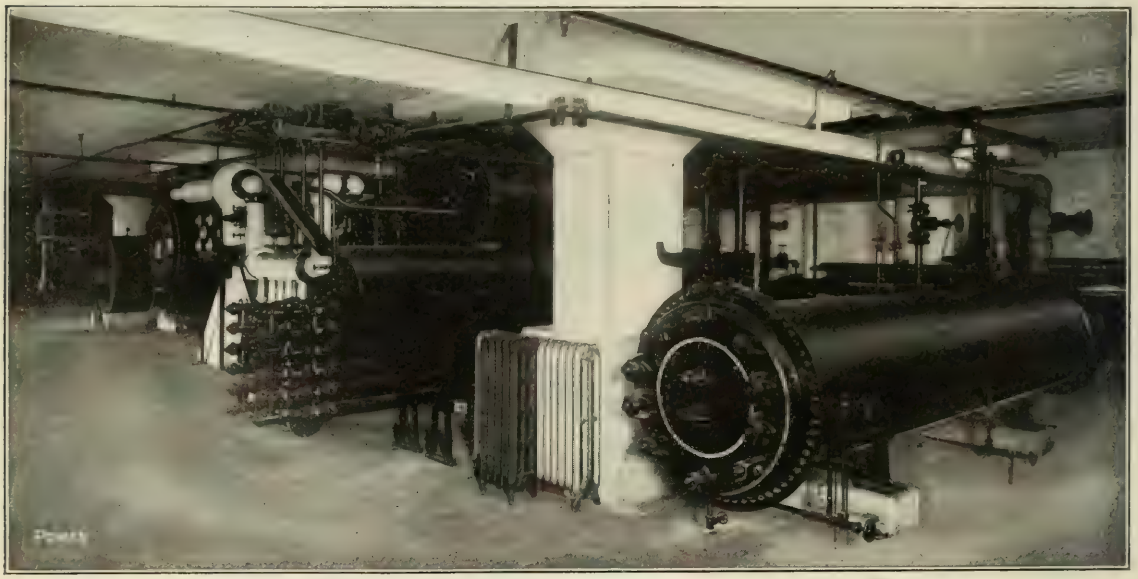


FIG. 8. FORTY-TON ABSORPTION PLANT

PRINCIPAL EQUIPMENT OF REID, MURDOCH & CO'S POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Water-tube	250 hp.	Steam generators	125 lb. gage, stokers	Babcock & Wilcox Co.
2	Stokers	Chain-grate	42.5 sq.ft.	Boiler furnace	Mechanical	Green Engineering Co.
1	Heater	Open		Heating boiler feed water	Metering heater, temperature 210 deg.	Harrison Safety Boiler Works
2	Engines	Four-valve	17x22 in.	Main units	200 r.p.m., 125 lb. initial, ½ lb. back pressure	Ball Engine Co.
2	Generators	Direct-current	200 kw.	Main units	Three-wire, 110-220-volt	Crocker-Wheeler Co.
4	Elevators	Electric		Freight		Pitt Engineering Co.
1	Elevator	Geared tractions		Passenger		Pitt Engineering Co.
1	Refrigerat'g system	Absorption	40 ton	Cooling storage rooms	Exhaust steam ½ lb. press.	Carbondale Machine Co.
2	Pumps	Single-cylinder	8x5x12 in.	Feed to boilers	125 lb. press., water supplied under head	Warren Steam Pump Co.
1	Pump	Centrifugal	3-in. suction	House pump	Motor-driven, 2400 r.p.m.	Alberger Pump & Condenser Co.
1	Pump	Centrifugal	3-in. suction.	Brine pump	Motor-driven	Alberger Pump & Condenser Co.
1	Pump	Duplex	7½x10-in.	Brine pump	125 lb. pressure	Warren Steam Pump Co.
2	Pumps	Single-cylinder	8x12x12	Vacuum pumps	125 lb. pressure	American Steam Pump Co.
1	Pump	Duplex	7½x6x10	Water to refrigerating condenser	125 lb. pressure	Henry R. Worthington
1	Pump	Centrifugal	3-in. suction	Water to refrigerating condenser	Motor driven	Alberger Pump & Condenser Co.
1	Pump	Double-acting	10x4½	Aqua pump	Power driven	Carbondale Machine Co.
1	Pump	Single-cylinder	10x4½x12	Aqua pump	125 lb. pressure	Carbondale Machine Co.
1	Pump	Duplex	18x10x12	For fire	125 lb. pressure	Fairbanks, Morse & Co.

Warren Webster air washing apparatus, American Blower Co. fans, Power's System of humidity control.

any window ventilation and the windows are permanently fixed. A small independent exhaust system removes air from the first-floor toilets.

Refrigerating System

This is a standard 40-ton Carbondale plant using exhaust steam at ½ lb. pressure to refrigerate the storage rooms in the sub-basement, and the fifth and sixth floors. There are a dried-fruit room, 60x120x11 ft. high, to be maintained at 40 deg.; a fish room, 60x80x11 ft., at 26 deg.; a cheese room, 60x12x11 ft., at 32 deg.; a nut box, which is cooled slightly, and a drinking-water cooling system with a centrifugal circulating pump. The rooms are constructed entirely of block cork and finished with cement plaster. The brine piping is insulated with Nonpareil cork. About 12,000 gal. of brine is circulated per hour; its temperature loss is to be 5 deg. The brine pipe in the refrigerating rooms is 1 in. in diameter, and there is a total of [illegible]600 lin.ft.

The plant has both steam and motor-driven aqua and brine pumps. The condenser, which is of the shell type and contains 1000 sq.ft. of surface, is supplied with river water by either a Worthington duplex steam or an Alberger motor-driven centrifugal pump, the former being for night service. There is an intake well in the dock to which are connected the two circulating and a 1000-gal. Fairbanks-Morse fire pump.

W. L. Fergus, consulting engineer, and T. W. McNeill, chief engineer of Reid, Murdoch & Co., are responsible for the layout and installation of the plant.

* * *

Will Quizz, Jr.

Dear Chief:

Since you have been away on your vacation I have been reading some, but I must write and ask questions: In the booklet entitled, "Valve Setting," which I received with my subscription to POWER, I notice it says that in making a half stroke of the piston the crank does not quite reach the perpendicular in a horizontal engine. Now, it does not go any farther in the explanation.

If the piston is past halfway of the stroke when the crank is at the quarter, what would prevent the piston striking the cylinder head before the crank got to the center? When the piston is in the center of its travel and the crank has not yet reached a quarter of its travel, how is the crank to gain twice the distance which it lacks from the perpendicular before it reaches the other center or before the piston finishes its travel? If you can explain this, I wish you would. I can't find a solution of it in any of my books.

Hoping to hear from you soon, I am

Respectfully yours,

WILL QUIZZ, JR.

Dear Will:

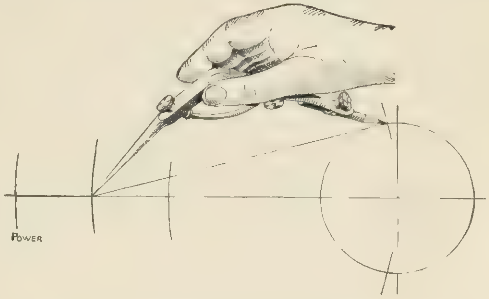
I am glad to note that you have been delving into your new booklet. "Valve Setting" does not enter into the discussion of the question you asked at length, because it is a book of instruction on setting valves of various kinds. It could not properly digress to discuss other subjects, even though closely related.

This question, like a great many other similar ones, either has been or must be learned by every enterprising young engineer at some time, and I am glad you asked it. Take that pair of dividers which has a pencil on one side (the two sides will be referred to as point and pencil) and do just as follows, and you will have the whole story.

First draw a horizontal and across it a vertical line. Set the dividers 2 in., and place the steel point where the lines intersect, and with the pencil describe a circle which will be 4 in. in diameter. Let this represent the crank circle. Now set your dividers 8 in., and do not change it as it now represents the length of a connecting-rod which in this case is twice the length of the stroke.

Place the point on the horizontal line at the left where the circle crosses it and make a short mark on the line with the pencil. This we will call the end of the travel of the crosshead pin toward the cylinder. Now make a similar mark on the horizontal line, using the opposite side of the circle. This will represent the end of the pin travel toward the crank. Now we have the equivalent of the crosshead travel (4 in.) which is identical with the piston travel.

From the center of the circle make a third mark which will be midway between these two points of travel. Then with the point on this last mark make a mark on the upper side of the circle and also one on the lower side, which you will find fall short of the vertical line.



WHY THE PISTON REACHES CENTER FIRST

Since you see the slant distance is greater than the horizontal and the connecting-rod does not lengthen, then, of course, when the crankpin has reached the vertical line the crosshead must have traveled beyond the mid position. With a constant speed of rotation the piston travels faster on the first and fourth quarters of the revolution than on the second and third. In other words, it travels further in a given time.

The handy old rule 6, 8 and 10 for getting two lines at right angles to one another will clear this up for you. Take a carpenter's square and measure across from the 8-in. mark on one side to the 6-in. mark on the other, you will find the distance is 10 in. These distances are referred to simply, because they are easy to remember and to verify. Any others may be used, but do not always give the result in even numbers. The rule is that when the horizontal distance is multiplied by itself (8 × 8 =

64) and the vertical also multiplied by itself (6 × 6 = 36) and these two added together (64 + 36 = 100) the sum will equal the slant distance multiplied by itself (10 × 10 = 100), as you can see it does.

This rule will work out the same way for a right-angle triangle of any proportion. Now, Will, don't get alarmed, this is no balloon trip. The square of the base plus the square of the perpendicular equals the square of the hypotenuse. It, therefore, follows that if any two distances are known the other may be obtained. For instance, if you have the hypotenuse (10) and the base (8), the square of the other will be the difference between the squares of these two, so 10 × 10 = 100, 8 × 8 = 64, 100 − 64 = 36, which is the square of some number (which means it is equal to some number multiplied by itself), which in this case you can easily see is 6 × 6 = 36. How to get the results by square root can be easily shown. If you want more of this at a later date, all you have to do is to write and ask for it. This will be all this time.

Your old chief,

TELLER.

⁂

Laying Out a Breeching and Stack*

By OSBORN MONNETT†

SYNOPSIS—Methods of obtaining dimensions applied to a plant having five water-tube boilers.

⁂

To illustrate the methods given in previous articles, a set of calculations to determine the dimensions of a direct-connected breeching and stack will be carried out for a plant containing five 410-hp. water-tube boilers equipped with the conventional vertical baffling and chain grates. A sectional view through one of the boiler settings is shown in Fig. 1, and Fig. 2 gives full dimensions for the breeching and stack.

The heating surface per boiler is 4100 sq.ft. and at a ratio of 50 to 1 the grate surface would be 82 sq.ft. The nearest commercial size of grate to give this surface is 9x9 ft., or 81 sq.ft. of actual area.

With ordinary Western bituminous coal it has been found that 5 lb. of coal per boiler horsepower is a good figure upon which to base calculations, and a good average evaporation for this kind of coal is 6.9 lb. of water from and at 212 deg. F.

The plant will be laid out on the basis of 50 per cent. overload, or an output of 615 hp. per boiler. This means that each grate must burn 3075 lb. of coal per hour or a maximum of

$$\frac{3075}{81} = 38\ lb.$$

per square foot of grate surface per hour. According to the curve shown on page 808 of the June 9, 1914 issue, it will require a draft of 0.46 in. over the fire to burn the 38 lb. of coal per square foot of grate surface per hour. On the basis of 24 lb. of flue gases per pound of coal, burning 3075 lb. of coal will produce

$$24 \times 3075 = 73{,}800\ lb.$$

of gas per hour.

To find the velocity of the gases and the proper size of breeching the volume of the above weight of gas at the temperature in the flue must be determined. For convenience the weight of 1 cu.ft. of air at different temperatures is given in Table 1, and as the difference in density between air and flue gases is so slight as to be negligible in practice, the values in the table will be used in the present design.

TABLE 1. WEIGHT OF 1 CU.FT. OF AIR AT DIFFERENT TEMPERATURES

Deg. F.	Lb.	Deg. F.	Lb.
400	0.046223	525	0.040364
425	0.04492	550	0.039365
450	0.043686	575	0.038415
475	0.04252	600	0.03751
500	0.041414		

Assume that the temperature of the gases at the boiler uptake is 500 deg. F. The weight of a cubic foot of gas at 500 deg. is 0.0414 lb. Therefore, the volume of 73,800 lb. of gas at a temperature of 500 deg. is

$$\frac{73{,}800}{0.0414} = 1{,}782{,}608\ cu.ft.$$

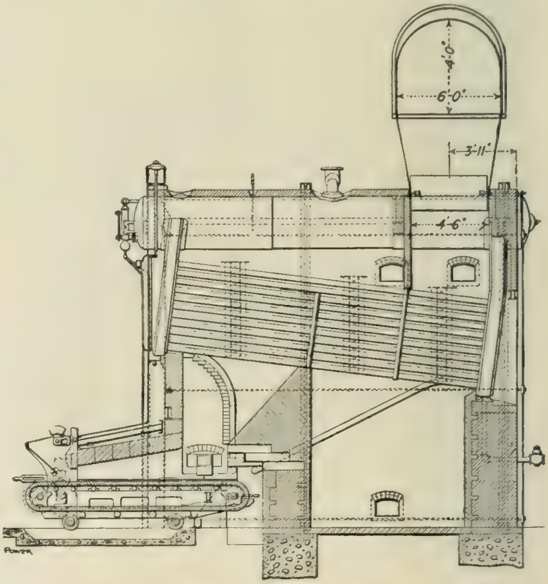


FIG. 1. TYPE OF SETTING EMPLOYED

This is the flow per hour and per second it would be

$$\frac{1{,}782{,}608}{3600} = 495\ cu.ft.$$

At 50 per cent. overload, the velocity in the breeching should not be more than 28 ft. per sec., and at this velocity the area of the breeching per boiler will be

$$\frac{495}{28} = 17.67\ sq.ft.$$

For five boilers this gives an area at the stack of

$$5 \times 17.67 = 88.35\ sq.ft.$$

The total connected grate surface is

$$81 \times 5 = 405\ sq.ft.$$

---

*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, city of Chicago.

so that the ratio of breeching area to total grate surface is 88.35 to 405, or nearly 1 to 4.5.

AREA OF STACK

A velocity of 30 ft. per sec. in the stack at 50 per cent. overload would give an area of

$$\frac{495}{30} = 16.5\ sq.ft.$$

per boiler, or 82.5 sq.ft. as the total area of the stack. This calls for a diameter of 10.25 ft. and a ratio of stack area to connected grate surface of approximately 1 to 5.

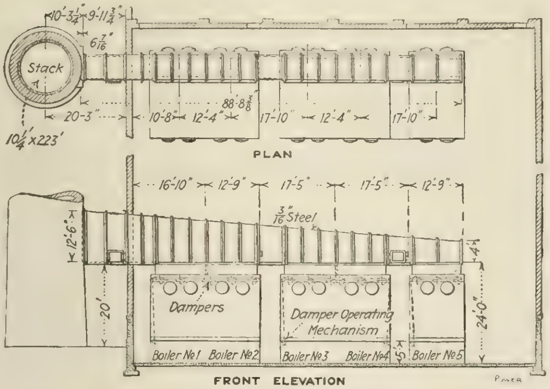


FIG. 2. LAYOUT OF BREECHING OF THE FIVE BOILERS

HEIGHT OF STACK

In finding the height of stack it is necessary to make an analysis of the boiler setting, dampers, uptake and breeching connections to arrive at the loss of draft occasioned by the design selected. Starting with the grate surface, a draft of 0.46 in. will be required over the fire. Referring to Fig. 4 on page 768 of the June 2, 1914 issue, it will be noticed that the loss of draft for this type of setting is 50 per cent., indicating that there must be 0.92 in. of draft at the stack side of the damper on the boiler farthest from the stack. From this point there is a run of 88 ft. to the stack, and for ordinary practice the drop through this length of breeching can be taken as approximately 0.2 in. Besides, there are four other boilers connected into the breeching which interpose an additional draft loss of

$$4 \times 0.05 = 0.2\ in.$$

making a total draft loss in the breeching of 0.4 in. and necessitating a draft at the stack of

$$0.92 + 0.4 = 1.32\ in.\ of\ water$$

The temperature at the stack will be approximately 475 deg., and the problem is to determine for this temperature the height of stack which will provide 1.32 in. of draft where the breeching enters the stack. Interpolating between the constants for 450 and 500 deg. given in the table on page 809, June 9 issue, a constant of 0.0065 is obtained for 475 deg. Then

$$\frac{1.32}{0.0065} = 203\ ft.$$

will be the theoretical height of stack required. Ordinarily, this is taken to indicate the height of the stack above the ground level. However, no stack or breeching layout gives the theoretical draft. There is always loss due to skin friction, leakage, etc. These losses are usually taken into consideration by using some empirical formula based on a number of assumptions. It is simpler in this case to assume that the height of 203 ft. is the height of the stack above the breeching connection, and as this is 20 ft. above the ground level, the total height of the stack will be

$$203 + 20 = 223\ ft.$$

This automatically furnishes a correction for friction, leakage, etc., without the use of any empirical formula and gives leeway to compensate for unexpected draft losses.

The above design will care for heavy fluctuations of load on individual boilers. One or more boilers will generally be down for cleaning or repairs, but with the liberal gas passes provided, the remaining boilers can easily be run above the designed 50 per cent. overload without trouble. In a plant erected according to these figures and now running successfully, the last boiler in the line has easily carried at intervals over 200 per cent. of rating.

∗

A Carnegie Tech. 750-Hp. Stumpf Engine

When the plans were prepared for additions to Machinery Hall, the Woman's School, the Applied Design Building and the Administration Building of the Carnegie Institute of Technology, bids were asked from three engine builders for a direct-flow engine, which type was invented by J. Stumpf, professor of steam engineering at the Royal Institute of Technology, at Charlottenberg, Berlin, Germany. The bid accepted was that of the Mesta Machine Co., which guaranteed a steam consumption of 27 lb. per kilowatt-hour.

The engine was delivered early in 1913. It is equipped with the type of valve-gear regularly built by the Mesta Co., but worked unsatisfactorily when started up. The *Tartan* of the institute states the cause as follows:

> On account of the short cut-off with which the direct-flow type of engine regularly works, the pressure disappears so quickly in the cylinder that the valve becomes unbalanced before the force of the vacuum pot has time to move it through its travel. This results in the valve gearing striking hard blows against the parts connected with the valve. Larger and more effective vacuum pots were installed, but after the engine had furnished power for the exhibition night of the school it was found that the piston had worn itself and the cylinder considerably. Careful study of the condition showed that the piston as originally designed was unbalanced. To overcome this trouble a new type of piston and a new cylinder bushing were made.
>
> A new and stronger rear cylinder head was also furnished to make doubly sure that no injurious deformation could occur in the valve seats.
>
> Nothing was done toward starting the engine during the summer, for the steam plant of Carnegie Tech is regularly shut down during the summer months. When the steam plant started up again in October there was not load enough to test out the engine to its capacity. It was not until Christmas that a rheostat was provided for loading the engine, the work of placing the rheostat in commission being done by an erector of the builders of the engine. While the engine furnished power for the schools during November and December, it was quite noisy, and it developed that the quick passing of the piston over the exhaust ports slammed the valves against their seats. Shoes were then provided which hold the valves on their seats continuously.
>
> In December the Mesta Machine Co. requested the Carnegie Institute to run the engine regularly. It was arranged that as a matter of precaution the interior of the cylinder should be inspected before the engineers of the Institute would undertake operation of the engine. To the surprise of everybody it was found that the cylinder had been slightly cut, due to steam blowing through a split in the piston rings for which no brass keeper had been provided, on the basis

the [illegible] of a suitable material for use with superheated [illegible] ence it was necessary to make and install the so [illegible] type of piston ring, which is perfectly sealed [illegible] events leakage of steam without a keeper.

[illegible] ince early in January the engine has been in regular [illegible] ation on the school load practically every day, picking [illegible] p the load at about 10:30 in the morning and carrying it until 10 at night. From 7 until 10:30 in the morning and from 10 until closing time at night the light load is carried by a smaller engine.

A test which was run on the Mesta engine indicated that the steam consumption is below the guarantee—that is to say, less than 2[illegible] lb. per kw.-hr., so that the steam economy is better than the guarantee called for.

Carnegie Tech is the first technical institution in the world to have an engine of the direct-flow type. The troubles which attended the early operation of the engine were not wholly unexpected, since any departure from existing practice, in spite of most careful study, usually requires some experimenting.

The Mesta Co. is at work designing a poppet valve-gear for this engine which will be thoroughly tested out before any change is made. Furthermore, there is no necessity for haste as the engine carries its load economically right along with the Corliss type of valve-gear.

⁂

Automatic-Cutoff Engines

By Alfred Butcher

Most engineers are interested in high-speed, automatic-cutoff engines, and wish to learn more about them, especially the governing device. To begin with, we will go back to the ordinary slide-valve engine with the throttling governor and observe the difference in the two types of governing mechanism, their speed in action and economy. With 100 lb. pressure on a throttling engine, the governor would regulate the pressure of steam admitted to the cylinder with a constant cutoff. It can be seen that steam has been raised to that pressure, but utilized at a lower pressure, as determined by the governor according to the load.

The diagrams *A* and *B* are drawn to make these statements clearly understood, where the height of the diagrams represents the pressure. The throttling-engine valve cuts off at the same part of the stroke at full as at friction load. The automatic engine at full load cuts off at about one-third the length of the stroke, but with a friction load the cutoff takes place early in the stroke. The average pressures of both full-load diagrams *Y* and *A* are the same, and the same is true at *Z* and *B* at friction load.

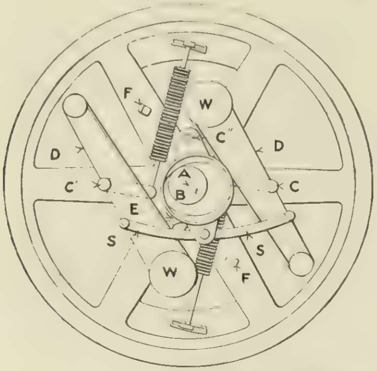


FIG 1 VALVE AT LONGEST TRAVEL WHEEL STOPPED.

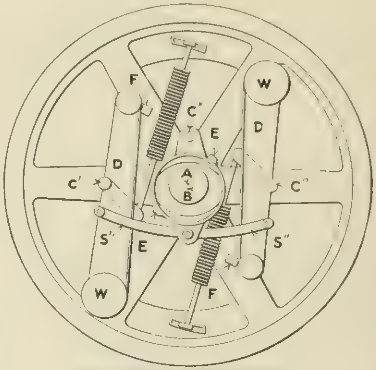
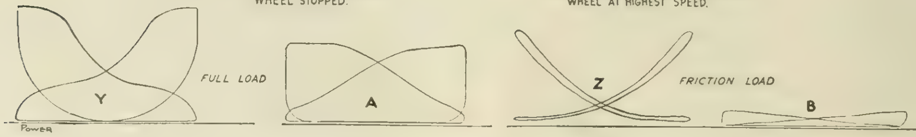


FIG 2 VALVE AT SHORTEST TRAVEL. WHEEL AT HIGHEST SPEED.



Comparison of Fixed and Variable Cutoff

The most important item is the expansion of the steam. The gain by expansion consists in the admission of steam at boiler pressure much above the average pressure required to do the work. An early cutoff, then, allows it to expand to a lower pressure toward the end of the stroke. The reason steam is so valuable to us is because of its expansive power.

In a throttling engine when the cutoff takes place at five-eighths or three-quarters of the stroke, it allows only three-eighths to one-quarter of the stroke for expansion before the exhaust takes place, and the expansion is wasted into the atmosphere; whereas in the automatic-cutoff engine we get the advantage of the expansive properties of the steam in the engine. Supposing the cutoff takes place one-fifth of the stroke, we get four expansions, or at one-sixth cutoff we get five expansions, etc.

We will now consider the governing of both types of engines. At one time the majority of electric plants had belted dynamos and throttling engines. With this type of governor, there is an instant of time lost before the engine will respond to the increase or decrease in load; consequently a flicker in the lights will be observed.

Later years, there has been more demand for direct-connected, high-speed engines with an automatic cutoff. The advantages claimed are more horsepower per floor space, better efficiency and close regulation. A small automatic-cutoff engine running at high speed can develop the same horsepower as a slow-speed engine of larger size.

When a locomotive engineer is about to open the throttle of his engine to haul a train, he first observes that his reversing lever is in the gear in which he wants his engine to run, such as "forward, or back gear"; when the train moves ahead at a desired speed, he has his throttle wide open, but he pulls his reversing bar a few degrees toward the reverse position. By doing this, as in all reversing engines, the valve travel is shortened; in other words, he is giving it a shorter cutoff, and using the steam more expansively. The result is less coal burned, quiet running and less water consumption, but still retaining the speed.

Although a locomotive is a throttling engine, and the engineer acts as the throttling governor, at the same time we may say that a locomotive is an adjustable-cutoff engine. The amount of shortening the cutoff, however, is at the discretion of the engineer.

With the automatic engine, the speed is governed by the length of time the steam is admitted to the cylinder at full pressure. The reverse is true of the throttling-governor engine, which admits steam for the same length of time but at less pressure. Fig. 1 shows a balanced type of flywheel governor. The center of the shaft is *A*, and *B* is the theoretical center of the eccentric. The distance from *A* to *B* is termed the radius of eccentricity. In this position the valve is at its longest travel. If the radius of eccentricity is 2½ in., then the travel of the valve would be 5 in.

One end of each spring is secured to the arms *D*, and the other end to the wheel proper. Limit stops are secured to the wheel to limit the travel of the arms *D*. Fig. 1 shows the springs holding the arms against the stops *E*, which are the longest travel stops, and Fig. 2 shows the arms *D* against the limit stops *F*, which are the shortest travel stops. This figure represents the position of the governor when the engine is at its highest speed. The governor is actuated by the centrifugal force of the weights *W* in motion, which have a tendency to fly away from the axis of the shaft *A* as the speed of the engine increases. The coil springs can be adjusted so that a certain speed is maintained, or, to be more exact, the position of the governor determines the point of cutoff of the valve to maintain a given speed.

The opposing forces are the springs, so that should a sudden load be thrown on the engine, the wheel has a tendency to slow up. The springs at this moment take charge of the lost centrifugal force of *W*, and bring the governor back toward the position in Fig. 2. Whatever load is on the engine, the radius of eccentricity *AB* is varied as the governor varies, so that the valve travel is measured by the position of the governor. The sleeve of the eccentric is independent of the shaft of these engines. In Fig. 1 the valve would travel 5 in., and in Fig. 2 it travels 2 in. The relations as to position between the crank and the eccentric are the same as on the ordinary slide-valve engines.

The crank would be in this diagram at the top half stroke; the angular advance of the eccentric can be seen in Fig. 1. All governors of this type are the same in principle. One may differ a little from the other in design—plate springs may be used instead of coil springs, and an eccentric pin or shank instead of an eccentric—but in all kinds the principles involved in governing remain the same.

⁂

Draining Steam Headers

By James E. Noble

There are many different ways to drain a steam header, but the methods shown in Figs. 1 and 2 are the best that the writer has seen in use.

Fig. 1 is a good method if there are several boilers in the battery and it is desired to tap the header in one place only. If Fig. 2 is used, the header must be tapped for each boiler; if only one boiler was tapped and it was out of commission for repairs, etc., there would be no way to drain the header.

When a drain is connected straight down from the header, as shown by the dotted lines (in which case the two elbows and check valve *C* are not used), there is likely to be a break in the connections, caused by expansion; therefore it is not good practice to make connections in this manner, although it is sometimes done.

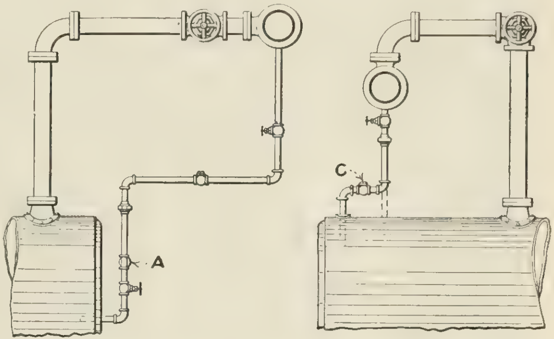


FIG. 1 FIG. 2

Two Kinds of Header Connections

In Fig. 1, *A* is a tee from which a pipe is run behind the battery of boilers and a connection taken off at each boiler with a valve and connections below it, as shown.

For a single boiler, the drain pipe, Fig. 2, should be of ¾ in. diameter, but if there are several boilers, nothing smaller than 1 in. should be used.

⁂

The Designing Engineer Coming to His Own—A thought that has long been in the minds of many engineers was expressed recently in the statement that "the day is coming when the engineer will occupy the position now held by the architect." The speaker said that the public or office building is primarily an engineering problem in which the architect "farms out" 75 per cent. of the work. Moreover, this percentage is constantly increasing. He took the ground that the design of such buildings really belongs to the engineer who should be in charge and, if necessary, "farm out" the architecture. It is easy to see how this proposition will strike the architects, yet its accomplishment is not such a remote possibility as might be imagined. In more than one engineering office at the present time there is maintained a distinct "architectural" department, so that the office which is primarily that of a designing engineer for heating, ventilating, electrical and sanitary equipment, is at the same time fully prepared to handle the other structural features, including the architecture.—"Heating and Ventilating Magazine."

Combined Steam- and Gas-Engine Plant

SYNOPSIS—To handle the extra load occasioned by an addition to the Fort Pitt Hotel, gas-engine units were installed. They are run almost exclusively during the summer and part of the time during the winter. With increased output, the total cost has been reduced by this combination.

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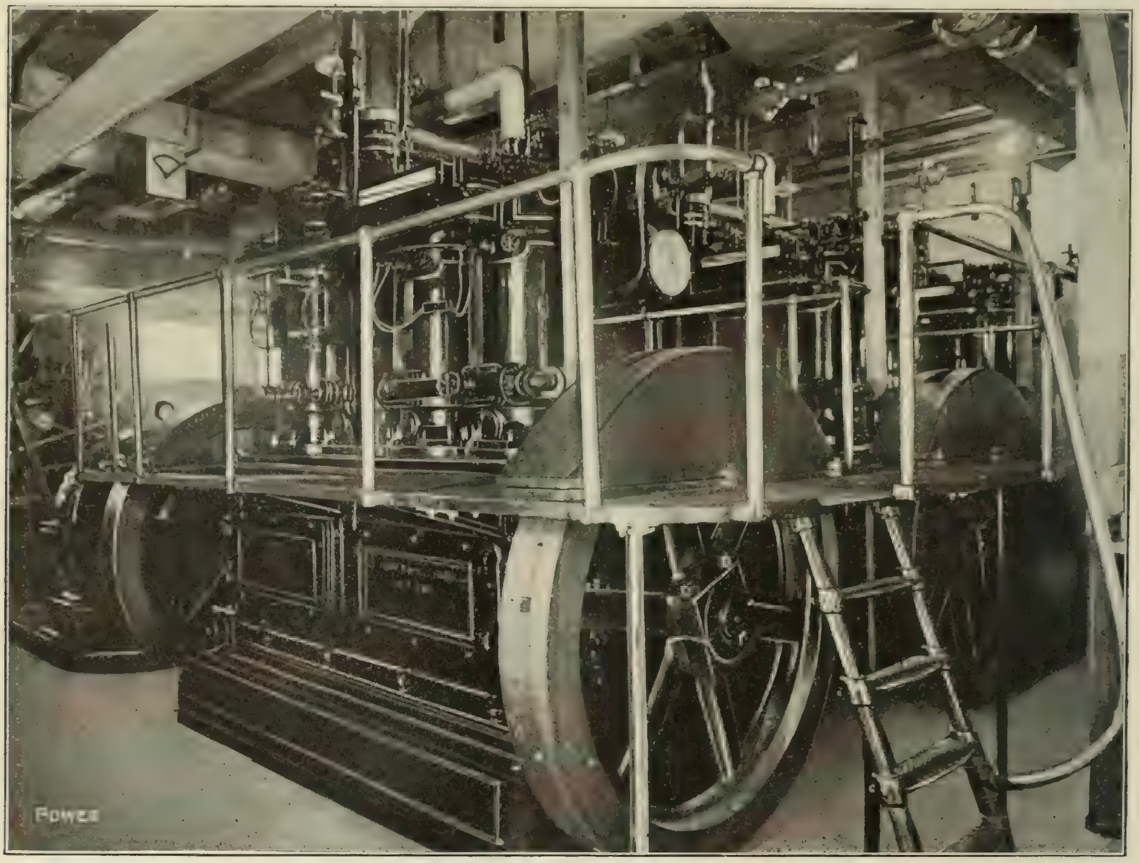

Gas-Engine Units in Fort Pitt Hotel

The Fort Pitt Hotel, of Pittsburgh, has its own power plant, which is a combination of steam and gas engines, the latter being installed in the fall of 1912 when the second addition to the hotel was made. The mechanical equipment consists essentially of three 316-hp. Heine boilers equipped with Roney stokers; two 250-hp. Erie-Ball four-valve engines; three 100-hp. slide-valve engines of the same make; and three 150-hp. Bruce-Macbeth, four-cylinder gas engines. Each of the engines is directly connected to a 125-volt direct-current generator. Besides the generating units there are two Frick ice machines, an air compressor for operating pneumatic tubes and air lifts, and the usual pumps, etc.

The three slide-valve engines were in the original equipment and are now seldom used. At all times enough steam equipment is run to heat the water by exhaust steam and in cold weather to heat the building. In summer the pumps and the ice machine furnish sufficient exhaust steam and the three gas engines are run almost continually. In winter the steam engines are run together with one or two of the gas-engine units.

For comparison of the straight steam plant with the combination steam and gas plant, two months are selected. January and June, 1912, and the corresponding months of 1913 after the gas engines had been added. During these periods the 30-ton ice machine ran almost continuously with an average of five tons of ice daily, the balance being refrigeration. The air compressor ran 24 hr. daily and the vacuum cleaner 12 hr., the two consuming about 200 lb. of steam per hour. The steam used in the kitchen averages about 20 boiler horsepower per hour for 24 hr.; that used in the laundry averaged 75 boiler horsepower per hour for 12 hr. a day in 1912 and 100 boiler horsepower for the same months in 1913.

The coal costs $1.70 per ton delivered and the natural gas 20c. per 1000 cu.ft.

The labor in 1913 was the same as for 1912, but there was an increase from 540 to 700 in the number of rooms served.

A COMPARISON OF FUEL COSTS DURING TWO MONTHS OF 1912 AND 1913

	January		June	
	1912	1913	1912	1913
Kilowatt-hours delivered	133,660	149,380	106,220	125,480
Gallons of water pumped	8,139,276	11,176,506	9,366,464	10,420,590
Cost of coal	$1,733.81	$1,474.07	$1,328.01	$885.95
Cost of gas	....	157.80	....	315.60
Cost of oil	84.16	94.06	89.95	103.64
Total cost (coal, gas, oil)	$1,817.97	$1,725.93	$1,417.96	$1,305.19

From the above figures it will be found that in January and June, 1912, 239,880 kw.-hr. were generated. The same months in 1913, when the gas engines were in use, 274,860 kw.-hr. were generated, an increase of 34,980 kw.-hr., or 15 per cent.

The water pumped in January and June, 1912, was 17,505,740 gal.; during the same months in 1913, 21,596,096 gal. were pumped, an increase of 4,909,356 gal., or 36 per cent.

The coal charges for January and June, 1912, were $3061.82 and oil, $174.01, making a total of $3235.83. For the same months in 1913 the coal charges were $2360.02, gas $473.40 and oil $197.70, making a total of $3031.12, which represents a decrease of $204.71, or 6.4 per cent.

The percentage of increase of steam used in the kitchen, laundry, for refrigeration, etc., could only be determined by exhaustive tests, but it is presumed that they have increased in somewhat the same proportion as the current generated. However, the figures show that the current generated has increased 15 per cent.; there is an increase in number of rooms of 29.5 per cent.; the water pumped has increased 36 per cent., and the fuel used has decreased 6.4 per cent. On a comparative basis of units of service, there was a decrease in cost of power, light, heat and water in 1913 over 1912 of 27.8 per cent., or a saving of 27.8 per cent. of the total cost of power by the addition of the gas engines. The cost of the gas-engine units, complete with foundations, piping, etc., was about $21,000.

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Steam-Electric Power Plant at Hauto, Penn.--II

By Warren O. Rogers

SYNOPSIS—Each double-ended, 1000-hp. boiler has four furnaces. Forced draft of 5 in. of water pressure is furnished by three 6-ft. motor-driven fans. The coal is switched over and discharged into coal bunkers, and the ashes and cinders, loaded into standard-gage ash cars, are hauled away by a locomotive kept expressly for this work and for hauling coal.

⁂

As stated in the first article on the Hauto plant, the boiler house is built at right angles to the turbine house, the ground floor being about 2 ft. below the level of the gallery in the turbine room.

The firing floor is at the level of the crane track in the turbine room, and above this floor is the water-tender gallery along the fronts of the boilers.

Boilers

At present there are eight 1000-hp. water-tube boilers, the superheaters superheating the steam 100 deg. F. The double-end, five-drum, bent-tube boilers are designed to carry 225 lb. pressure, and the heating surface, exclusive of the superheaters, is somewhat in excess of 10,000 sq.ft. The center steam drum is 48 in. and the two outside steam drums, and the two mud drums are 42 in. in diameter and 23 ft. long; all are double-butt-strap jointed and double riveted.

The boilers are in a row on the stall system lengthwise of the boiler room. In the case of the six boilers, provisionally provided with hand-fired grates, the furnaces are 8 ft. wide and 12 ft. long, giving a grate area of 96 sq.ft., a total of 384 sq.ft. per boiler, or approximately 26 sq.ft. of heating surface per square foot of grate area. The adjoining furnaces are separated by a firebrick wall 35 in. thick and reach to the arches at the top of the furnaces. The bridge-wall separating the four furnaces at the center of the setting is 31½ in. wide and extends 3 ft. 1 in. above the rear end of the grates, which are 1 ft. lower at the back than at the front. The bridge-wall is ventilated by means of air ducts, arranged as shown in Fig. 6, air being supplied from a main intake. The air ducts are 3 in. in diameter and extend through the bridge-wall to the outside of the setting.

Furnace Arches

Between the boiler drums and the grates there are three sets of arches for each hand-fired furnace. The bottoms of the mud drums are protected from the direct action of the furnace heat by firebrick walls, Fig. 6. The boilers are designed with tubes six rows deep from the mud drum, running to the center steam drum. The outside steam drums are connected with the mud drum by tubes five deep. Baffles are placed between the larger bank of tubes and the superheater, and between the superheater and the outside bank of tubes for each half of the boiler.

Heated gases from all four furnaces pass to the center of the boiler and, striking the inside bank of tubes and baffle walls, go to the second pass, where the superheater is located, and then to the last section of the boiler, escaping to the stack.

Each mud drum is 7 ft. 9 in. above the grates. Between the brickwork and the supporting I-beams, insulating materials protect the metal from the furnace heat. The supporting arch is nearest the mud drum and is 9 in. thick, as are the other two arches; the lower one is curved to an 8-ft. radius; they are connected to the side walls, as in Fig. 7, which gives details of construction. The bottom arch extends 7 ft. 10½ in. into the furnace, the other two 9 ft. 4½ in., which brings them just beyond the inside brickwork around the mud drum. The spaces between the arches are filled with suitable packing to a depth of 11 in. from their rear, and a limited amount of air is allowed to circulate through the spaces from openings at the furnace front.

CINDER AND ASH DISPOSAL

A pair of inverted hoppers at the bottom of each rear pass take care of the cinders deposited in the last pass of the boiler. The cinders settling on the hoppers run by gravity to the discharge chutes extending to the boiler-room basement, along the sides of the ash hoppers, where they discharge into the ash cars, Figs. 8 and 14. Each of the 32 ashpits has a $\frac{3}{16}$-in. thick metal hopper, stiffened with angle iron and lined with brick placed upon reinforcement bars carried through holes molded in the brick. Each ash car is air dumping and righting. This is accomplished by either of two air cylinders, one on each side of the car, using air from the locomotive handling the ashes and coal. The car body rests on pivot points along the center from end to end. A chain attached to the piston on each end of each cylinder is also hooked to a lug at each end of the car. When the ashes have been hauled to the desired dumping place (ashes are used for filling in at present), air pressure is admitted from the locomotive tank to one set of cylinders and the load is dumped, the piston and chain tipping the car to one side. A reverse motion of the piston in the opposite cylinder restores the car body to its original position.

FURNACE GRATES

Six of the boilers have hand-fired dumping grates designed for burning anthracite coal of the finest practicable size. Four of these grates have slotted tops $\frac{3}{32}$ in. wide and two are pinhole top grates, with 6 per cent. air spaces. These are at the bottom of the grooves formed across the tops of the grates at right angles to each other.

The other two boilers will be equipped with traveling grates, one with removable piano-key grate tops supported on carrier bars, the other with removable pinhole grate plates. The lateral expansion of the piano-key tops is compensated for by expansion plates supported at each end of the carrier bars, as are also the grate tops. Inclined springs attached to the plates pulling from the sides toward the center force the tops of the plates to-

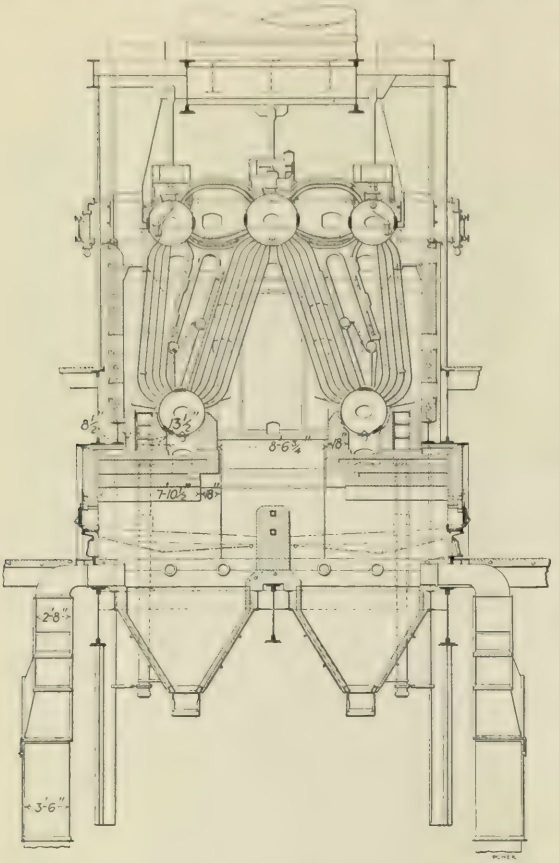
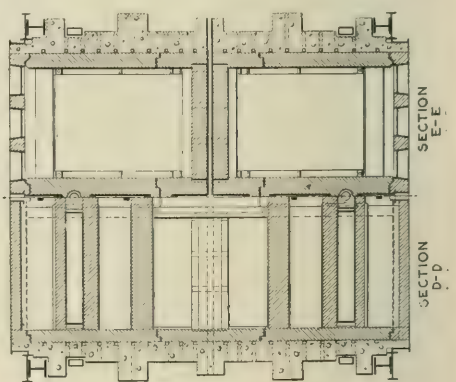
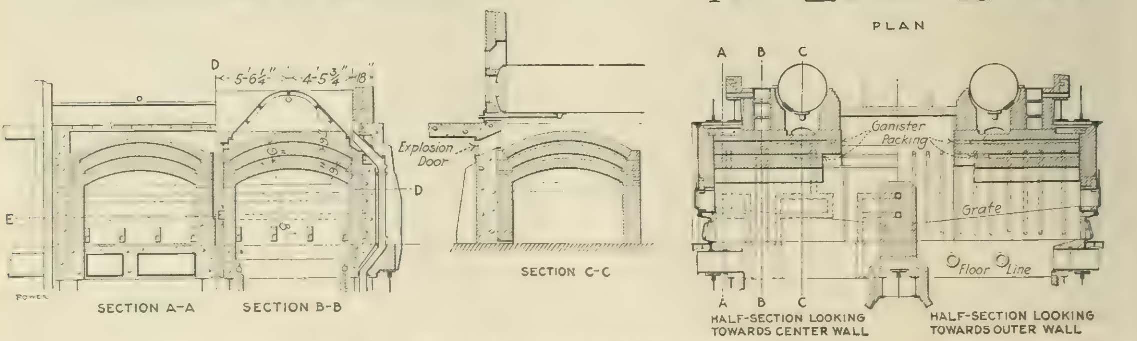


FIG. 6. SECTION THROUGH ONE OF THE 1000-HP. BOILERS, SHOWING THE ARRANGEMENT OF THE FURNACE ARCHES AND BRIDGE-WALL



PLAN



SECTION A-A SECTION B-B SECTION C-C

HALF-SECTION LOOKING TOWARDS CENTER WALL

HALF-SECTION LOOKING TOWARDS OUTER WALL

FIG. 7. DETAILS OF FURNACE-ARCH CONSTRUCTION

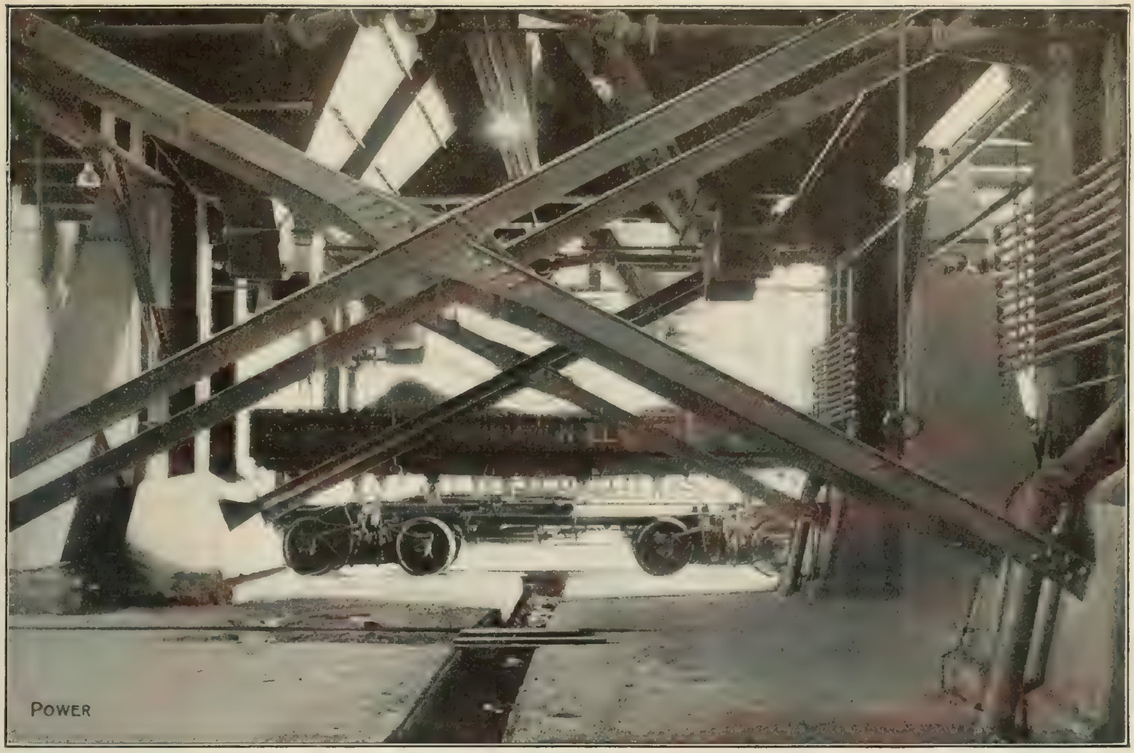


Fig. 8. Ash Car under Ash Hoppers and Discharge Pipes from Cinder Hoppers

gether. Both types of grate top overlap each other in the direction of travel to prevent the fuel from sifting through to the ashpit. Fuel will be fed by gravity from the bunkers to a hopper above the grates.

Furnace

Each hand-fired furnace has three sliding firing doors, Fig. 9, or 12 for each boiler. At the top of each door a rod extends upward and is attached to a tilting arm pivoted on the girder shown. On the outer end there is a balancing weight so adjusted that the door will remain in any position. A pull rod of suitable length enables the fireman to manipulate the furnace fire-doors.

As the sliding doors prevent the escape of steam and water in case of a bursting tube, three explosion doors have been provided in each side of the boiler setting. They

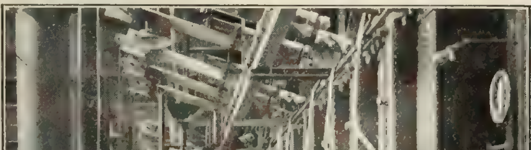


Fig. 9. View Along the Firing Aisle on One End of the Eight Boilers

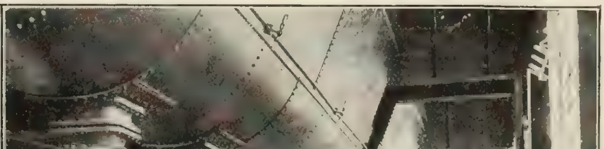


Fig. 10. Water Tenders' Gallery and Coal Bunkers at One End of the Boilers

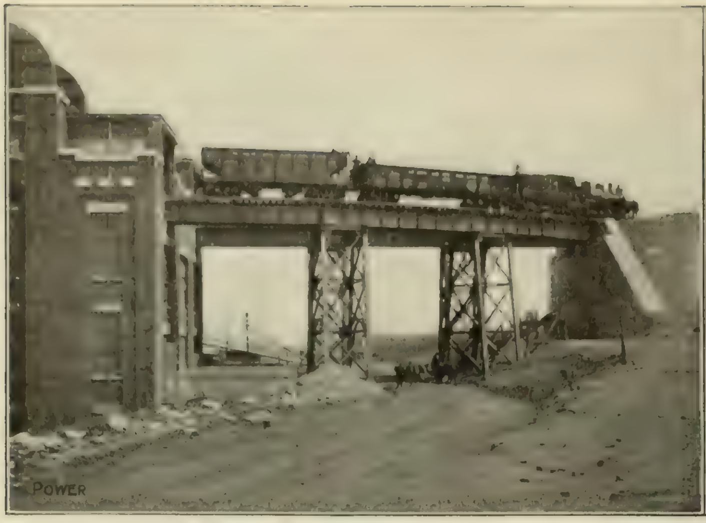


Fig. 11. Locomotive Handling Coal Cars on Trestle to Coal Bunkers

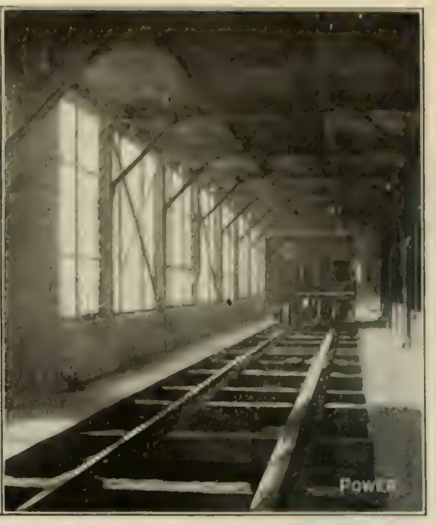


Fig. 12. Coal Car over Coal Bunkers

connect with the first pass of the boiler, and are 18 in. wide and 14 in. high. The two lower ones are 2 ft. 8 in. above the mud drum and are opposite each large bank of tubes. The top doors are 15 in. below the center steam drum, and central between the two inner banks of tubes, Fig. 6. In case a tube bursts, these doors are blown open and damage to the setting is prevented.

Four water columns on each boiler, two above each firing aisle and at opposite ends of the boiler, are connected to the center steam drum, although the bottoms of the three steam drums are on the same level. By this arrangement the water tender can determine the water level from each end of the boiler. The drums are tied below the center line by two sets of 3-in. tubes and above the center line by one set. The lower tubes are baffled above the top tubes and between the top and lower ones.

The steam drum and top tie tubes are covered by 5 in. of brickwork, over which 1¼ in. of asbestos cement is placed. Besides the four safety valves on the drums of each boiler there is also a valve on the discharge side of each superheater.

Fuel Supply

Above the firing aisle is the water tenders' gallery, Fig. 10, and in the foreground may be seen the coal chute to the firing floor below. The six vacant spaces are for the spouts that will lead to the hoppers of the traveling grates.

There are four bunkers on each side of the boiler room, each bunker serving two boilers and holding 867 tons, or a total of 6936. These are single riveted and unlined.

Coal is hauled direct from the washeries to the bunkers, the cars being handled by a logging type of locomotive equipped with three cylinders on one side of the boiler, next to the cab. The crank rods drive a shaft geared to the driving wheels, a sliding coupling permitting the train to run over extremely sharp curves. Fig. 11 is a view of the engine and two empty coal cars. Fig.

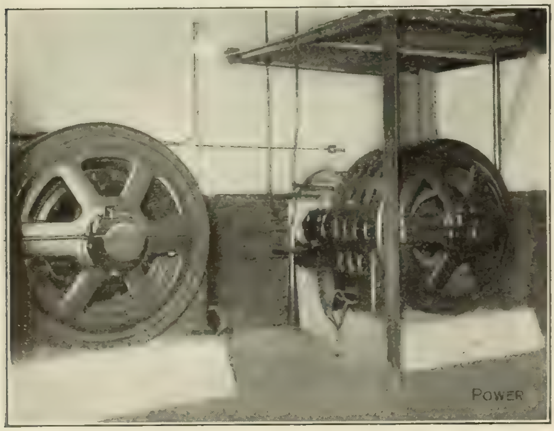


Fig. 13. Two of the Three 450-Hp. Induction Motors Driving the Forced-Draft Fans

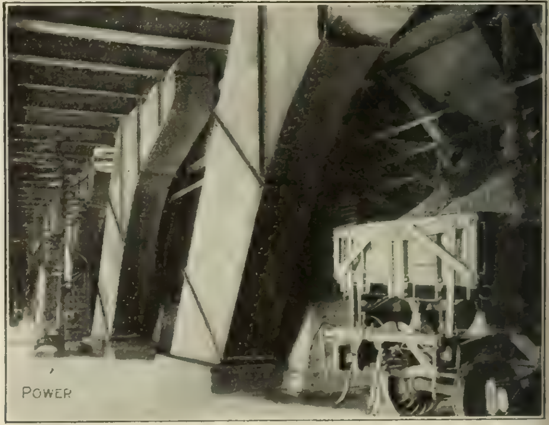


Fig. 14. Air Ducts Leading to Boiler Ashpits from Main Underground Duct

12 shows a coal car above the bunkers ready to be unloaded. The rails are secured to heavy I-beams and the coal is dumped from hopper cars into the bunkers. The arrangement for handling coal and ash does away with all coal- and ash-conveying apparatus other than the locomotive which was used for handling material during the construction period.

All the boiler furnaces have forced draft, which is obtained from two of the three motor-driven fans in two fan rooms on a level with the turbine-room balcony and between the header room and the boiler-room basement.

Each fan is 6 ft. in diameter, 6 ft. long, and has a capacity of 22,900 cu.ft. of air per minute at 360 r.p.m., or a total of 68,700 cu.ft.; each is driven by a 450-hp. induction motor, Fig. 13, directly connected to the fan shaft. Sufficient air can be supplied by two blowers for the eight boilers under full load. Air is taken from outdoors, from the top of the boiler room or else from the turbine room through the pipe gallery.

Air from the fans is blown into two main concrete air ducts placed under the floor of the boiler-house basement beneath each firing aisle. These ducts are cross-connected at the end nearest the blowers, and any blower may be used to supply air to both tunnels. One serves all of the furnaces on the ends of the boilers to which it is connected, the other connecting with the furnace on the opposite ends. The ducts, 14 ft. high and 2 ft. 6 in. wide, extend the length of the boiler room.

The first two boilers are served by a single Y-branch duct, (Fig. 14) 12 ft. wide and 3 ft. 6 in. across, the latter is also the dimensions of the single-branch ducts serving the remaining boilers, which are 8 ft. wide at the bottom. At the top, however, the width of the ducts increases to 19 ft., and reduces to 2 ft. 8 in. across. Each has four outlets, two to each furnace, which enter the ashpit at right angles to the branch duct and have dampers operated by the firemen by means of a lever and connecting-rods. The ducts entering each ashpit are of two sizes, one being 2 ft. 7 in. and the other 4 ft. 1 in. wide; both are 17 in. high, thus giving a total duct area at the ashpit of 1360 sq.in., a total for each boiler of 5440 sq.in.

Emergency provisions have been made for supplying the furnaces with forced draft by means of air-jet blowers, two being provided for each furnace.

The furnace gases escape from each last pass of each boiler to a vertical smoke flue of sheet metal, lined with insulating material below the roof line. They are of peculiar design, Figs. 15 and 16, to permit installing economizers at some future date by removing the side plates, Fig. 16, which will allow of connecting with the intake of the economizer; the outlet will connect with the opening now sealed by the top horizontal plate. The connection to the chimneys is shown in Fig. 15, also the tracks to the coal bunkers; the reservoir is shown at the left.

There are four steel stacks 157 ft. above the grates and 12 ft. inside diameter, or an area of 113.1 sq.ft., a total of 452.4. Each stack takes the furnace gases from two boilers, thus serving 768 sq.ft. of grate area. The chimneys are supported by the roof trusses; the stack cinders are collected at the bottom.

The third installment will deal with the piping system of the Hauto plant.

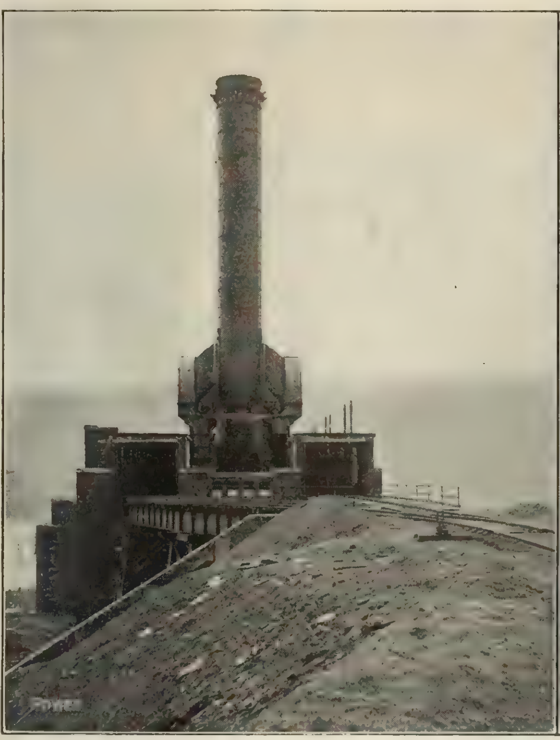


Fig. 15. Showing Connections of Uptakes to Chimney, Tracks and Reservoir at the Left

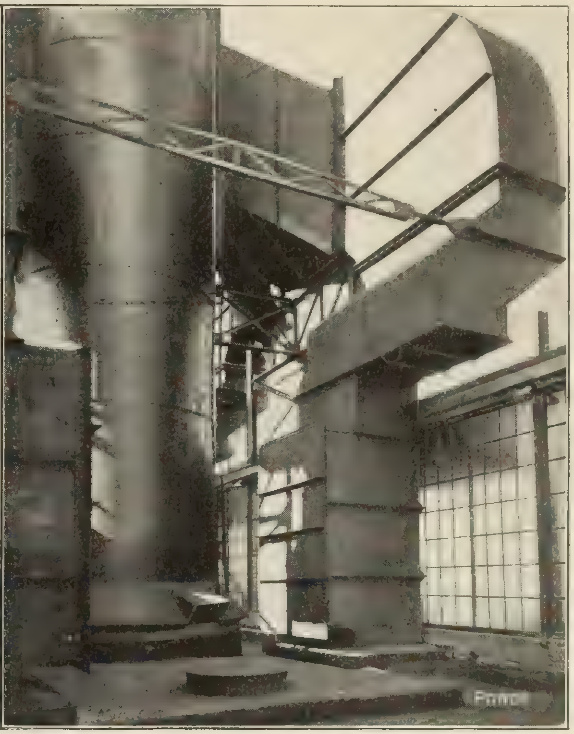


Fig. 16. One of the Uptakes, Showing Connections for Future Installations of Economizers

Tests of Van-Stone Joints

To determine the relative merits of steel pipe, van-stone joints and acetylene welds, a series of tests were undertaken by the Simmons Pipe Bending Works at their plant at Newark, N. J., Tuesday, May 12, before a gathering of engineers.

A hydrostatic test was made on a 10-in. full-weight steel pipe, 5 ft. 6 in. long, one end of which was equipped with an ordinary van-stone lap joint with specially designed cast iron heads, Fig. 1; the other end had a dished head, welded in by the oxyacetylene process. A water pressure of 3000 lb. per square inch was applied to the pipe without causing any perceptible change to the section. This test is to be repeated, carrying it to the bursting point.

A 6-in. full-weight steel pipe, 4 ft. 6 in. long was next submitted to a bending stress, the load being applied at the center. This pipe failed at a load of 16 tons, with a deflection of 2 in., Fig. 2.

Two 6-in. full-weight steel pipes, 4 ft. 6 in. over all and welded in the center by the oxyacetylene process, were subjected to a central load applied at the weld. This

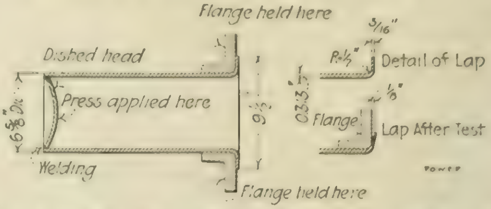
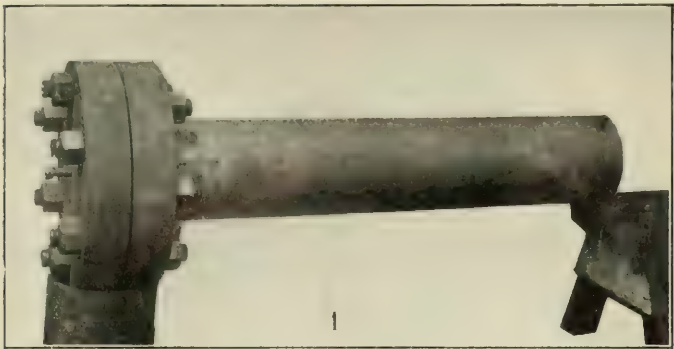


Fig. 1. Type of Van-Stone Joint and Details of Lap before and after Test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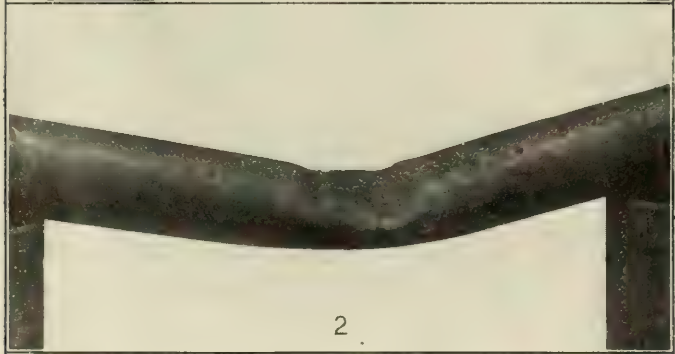
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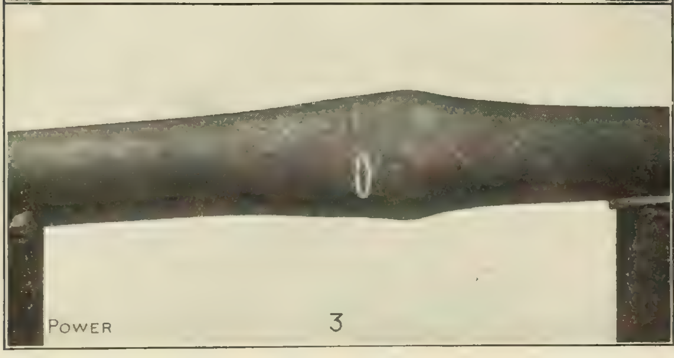

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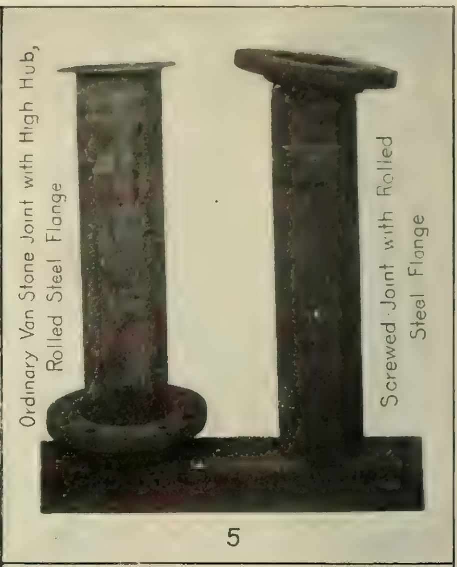
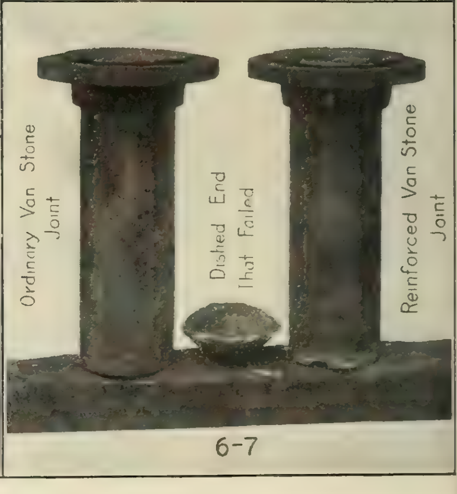

Ordinary Van Stone Joint with High Hub, Rolled Steel Flange
Screwed Joint with Rolled Steel Flange
5



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Showing Result of Tests on Steel Pipes and Flange Joints weld failed under a load of 18 tons, with a deflection of 2½ in.; at 16 tons the deflection was 2 in. The piece failed at the weld on the tension side, the weld opening $\frac{1}{32}$ in. for a length of 2 in., Fig. 3. The type of weld is shown in Fig. 8.

The next test was of two pieces of 6-in., full-weight steel pipe, 4 ft. 6 in. over all, one having an extra-heavy rolled-steel flange screwed up; the other piece was fitted with an extra-heavy, high-hub, rolled-steel flange with ordinary van-stone lap. These two flanges were bolted together, and load applied at the center. One pipe failed under 12 tons pressure, breaking at the threads. The deflection at the instant before breaking was 1 in. Fig. 5 shows the result of the test, the van-stone lap being bent ¼ in. out of line.

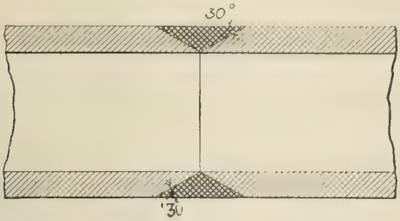


Fig. 8. Type of Weld

The fifth test was with a 6-in., full-weight steel pipe, one end of which was plugged with a dished head welded in by oxyacetylene; the other had an ordinary van-stone joint. This piece was inserted in the test press, and pressure was applied tending to draw the lap through the flange. The lap started to straighten at 20 tons; the pressure was then carried to 60 tons without further change (see Fig. 6).

The same test was made on a pipe with a reinforced van-stone joint, a lap turned back upon itself. The lap started at 20 tons pressure and was then carried to 60 tons when the dished head failed at the weld, Fig. 7.

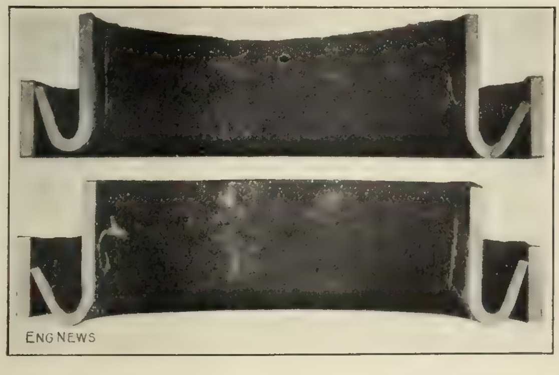


Fig. 9. Forcing a Van-Stone Joint through a Pipe at 53 Tons Pressure

Another interesting test to prove that the van-stone joint is strong enough for any normal service was run in March. The van-stone flange on a 10-in. pipe was hammered flat, cold; the outside diameter of the pipe and lap was 14½ in. The pipe was placed against a 14-in. pipe and pressure applied. The van-stone lap on the 10-in. pipe was bent back and the pipe pushed cold through the 14-in. piece under 53 tons pressure. The lap was not fractured. The final condition of the lap is shown by Fig. 9.

Facilities were also given to see bending, welding and van stoning. The tests were in charge of M. Wesney Ward, mechanical engineer, New York representative of the Simmons Pipe Bending Works, 30 Church St., New York City.

⁂

Locating Trouble in Air Compressor

By T. G. Thurston

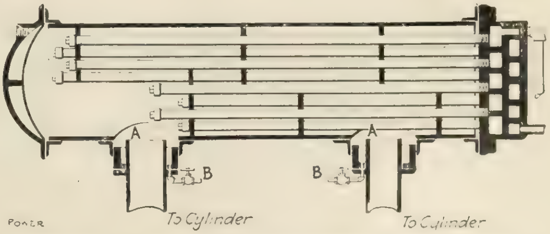
A large two-stage, cross-compound air compressor, the discharge pressure being 120 lb. and the receiver or intercooler pressure normally about 30 lb., was hurriedly installed. For a few weeks it ran well, then a knock developed in the high-pressure cylinder. The knock came at irregular intervals and the receiver pressure began to gradually increase week by week.

When the high-pressure discharge and inlet valves were taken out they were corroded and badly gummed, and a large amount of grit and dirt had accumulated on them and in the discharge ports.

The valves and ports were cleaned, the valves replaced, and upon starting the compressor worked a little better, although the receiver pressure did not come down to where it should. A few days later the knock again announced itself and the receiver pressure gradually increased to 60 lb.

The low-pressure journal bearings pounded badly, due to the excessive receiver pressure. Then the high-pressure cylinder was opened and the piston taken out. A piece about 3 in. long was found broken out of each ring and the rings were worn down to ⅛ in. in places. The air passages from the discharge side were filled with a gritty, gummy substance resembling brick dust mixed with oil, and some of it was baked quite hard.

The intercooler was placed horizontally across the two air cylinders, as shown in the illustration. Much water accumulated and found its way into the pockets *AA*, around the air passages leading to the air cylinders. These were provided with pipes and valves for drawing the water off regularly, but this had not been done as often as necessary, and, consequently, the water got into the high-pressure cylinder. Added to this, the air had been taken from the basement directly under the compressor, which was damp and full of dust from the construction work going on.



Sectional View of Intercooler; Note Drains

Two new rings were made for the piston, the air intake was piped to the roof and a trap connected to the two pipes *BB* to insure the water being taken away as fast as formed. When the compressor was started the receiver pressure showed only 27 lb., and the machine ran quietly and has not caused any further trouble.

❦

Self-Synchronizing Rotary Converters

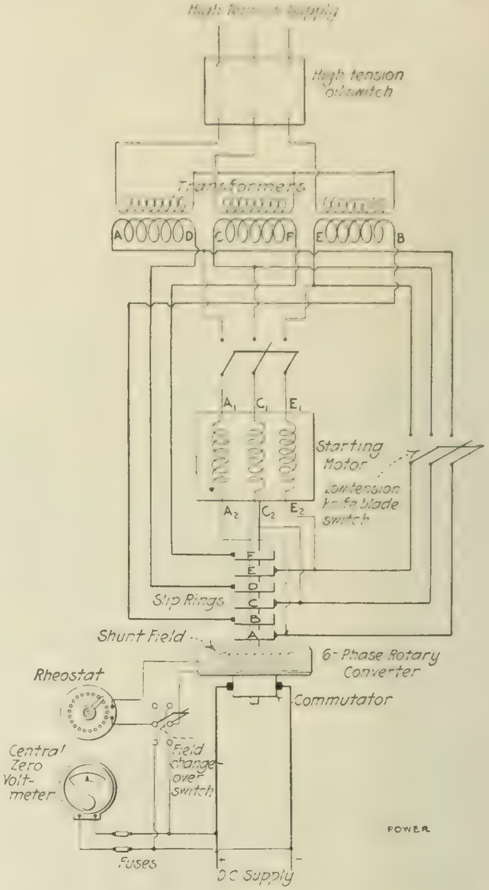
A new method of making rotary converters self-synchronizing is being adopted extensively by British manufacturers. With it the complications of a synchronizing gear and starting taps on the transformers are avoided, and the delicate operation of synchronizing is dispensed with. The starting current required is also reduced to the lowest practicable limit. There is a squirrel-cage starting motor with each converter, its stator being wound for the voltage of the main transformer secondaries. The electrical connections are shown in the diagram.

It will be seen that each of the three phases of the stator of the starting motor can be connected in series with the converter slip rings. The gear consists of the usual three-pole, high-tension switch on the primary side of the transformers, a three-pole, low-tension switch in the main alternating-current circuit to the converter, a smaller three-pole switch for the starting-motor stator circuit, a central zero direct-current voltmeter, and a field change-over switch. At starting, all these switches, including the field switch, are opened and the oil switch on the high-tension side of the main transformers is then closed. Now, upon closing the motor-starting switch, the low-tension alternating-current circuit is completed through the starting-motor stator, and the machine starts. Owing to the high impedance of the starting-motor windings, the starting current is reduced to a small amount, with the result that no sparking takes place at the commutator, and none of the disturbances incidental to heavy starting currents is created in the alternating-current system. These two are most important points and constitute the chief advantages claimed for the new method of synchronizing.

When the converter passes through the synchronous speed, the voltmeter pointer will oscillate between a small positive and a small negative indication, or *vice versa*, every time a pole is slipped. If the converter-field switch is closed when the voltmeter indicates the proper polarity, the converter will excite and remain steadily in synchronism. After adjusting the field so as to show approximately the correct normal voltage, it is necessary only to short-circuit the starting-motor stator by closing the main low-tension alternating-current switch. The converter being in synchronism before this switch is closed and excited to full normal voltage, the closing of the switch causes neither a heavy rush of current nor any sparking at the commutator.

An indicating lamp is sometimes connected across the main low-tension switch. This lamp will flicker before synchronism is reached, and will be dark after synchronism. However, since complete indication of synchronism is given by the voltmeter, this lamp is not essential.

Moreover, the three-pole switch in the starting-motor circuit is not essential; it is provided merely for convenience. If this switch were not provided, the converter would start as soon as the high-tension switch was closed. If the latter is in close proximity to the converter, there is, of course, no objection to this arrangement. It should also be noted that, under certain conditions, the field circuit may be closed before the starting operation commences. There is no danger of the machine coming up with the wrong polarity under these conditions, because the starting current is too small to interfere with the residual magnetism already existing in the machine.



WIRING OF SELF-SYNCHRONIZING CONVERTER

Tests on actual machines show that, with this new method, rotary converters of 1500 kw. and above can be started and synchronized in from 30 to 50 seconds.

❦

One Dollar per Kilowatt per Month—The electric current used in the Rupert High School, Rupert, Idaho, comes from the government power house at Minidoka Dam, 14 miles above Rupert, on the Snake River. It is distributed by the Rupert Electric Co., and sold at $1 per kilowatt per month, for heat, flat rate. The current passes through a transformer of 300 kw. capacity, three-phase, Westinghouse self-cooling type, filled with oil. This transformer will stand an overload of one-third, so that a maximum of 400 kw. is available. The transformer is fed from the 4000-volt, four-wire distributing system of the Rupert Electric Co. by underground cable. This school is said to be the first large building in the world to be heated by this system of electric heat. The board of education and the superintendent of schools had such faith in the feasibility and economy of the system that the building was erected with absolutely no provision for the installation of any other heating system.—"Heating and Ventilating Magazine."

Editorials

Does Superheated Steam Dissociate?

Are there different kinds of superheated steam?

We do not now refer to the possibility of the existence of unevaporated moisture in a mass of superheated steam, the temperature of which is above the boiling point of the moisture. It has been demonstrated, if it needed demonstration, that water can exist for a limited time in an environment the temperature of which is above its boiling point just as a cake of ice can endure for a time on the curb in the sweltering sunshine of a summer's afternoon.

This discussion points in the other direction—up the scale, to dissociation.

E. A. Geoghegan claims to have a superheater the product of which is so much different from the steam put out by the garden variety of superheater that it can be used at over nine hundred degrees with impunity and oil hemp packing, whereas the degree of superheat which can ordinarily be usefully applied is limited by its effect upon the lubrication, packings, fittings, etc., to from one hundred to two hundred degrees.

The reason, according to Mr. Geoghegan, lies in the fact that in his superheater the temperature of the steam is brought up gradually, avoiding any tendency to decomposition, while with most other types a thin sheet of steam is impinged against surfaces at almost a red heat, affording ample opportunities for local heating above the thirteen hundred degrees needed for decomposition in the presence of iron or steel of that temperature. The oxygen eats up the superheater and the liberated hydrogen goes on to play heck with the engine and piping.

If this condition exists, it would be well to establish the fact and correct it. Cases have occurred where superheaters have oxidized badly, but they have been exceptional. Mr. Geoghegan claims that if a torch be held in front of a two- or three-inch outlet in a pipe leading from some types of superheaters carrying, say, two hundred and fifty degrees superheat, and the valve controlling the outlet be opened and closed quickly, there will be a very noticeable explosion of the hydrogen present in the steam. If this is so it ought to be easily capable of positive demonstration, and even the amount and composition of the gas determined.

The dissociation of steam at thirteen hundred degrees is not a spontaneous agreement between the atoms of hydrogen and oxygen that things have become too hot for them to get along together, but to the interference of the interloper steel or iron, for which, at thirteen hundred degrees, the oxygen has a greater affinity than for the hydrogen. If decomposition does take place in this way it is a serious matter, for each pound of steam so decomposed would eat up more than two pounds of superheater.

Dr. Augustus H. Gill, of the Massachusetts Institute of Technology, in an article discussing the decomposition of steam, in POWER of Jan. 28, 1913, cites Lowenstein and Wartenburg as having shown in 1906 that at two thousand and sixty degrees Fahrenheit (about the melting point of average cast iron) steam was but 0.0086 per cent. decomposed, and even at a temperature but little above that of melting wrought iron (twenty-nine hundred degrees Fahrenheit) only one-third of one per cent. was dissociated. This means that in cast-iron or wrought-iron containers practically no steam can be decomposed into hydrogen and oxygen; and if there were any of these gases formed, inasmuch as the reaction by which they are formed is under the conditions a reversible one, that they will recombine the moment the temperature is lowered.

In view of this a demonstration of the existence of the conditions claimed by Mr. Geoghegan is essential to the serious consideration of the merits of his system. Such a demonstration is easily possible, but so far as we know is yet to be made.

* * *

Summarizing Power-Plant Operating Reports

It is widely believed that in large plants only is it worth while to maintain exhaustive records of operation. This is a mistake. Besides, the fundamental data relating to fuel consumption, labor costs, supplies and repairs recorded, there is a field for analysis which offers a sure reward to the student of station economics. In this branch few are more interesting than summaries of operation upon a weekly, monthly and yearly basis.

Engineers prefer to make up their own forms of log sheet, but the good points in others may be profitably incorporated insofar as they fit the conditions. Power-station accounting varies as much as does that of other departments, but the opportunity for the standardization of summaries within the plant and for comparisons with other stations of similar or different types is sometimes overlooked.

The summary sheet of a large turbine plant in which more than usual attention is paid to record keeping contains about fifty items and nearly seven hundred entries in the course of a year. The items need not be enumerated in detail, but an outline is suggestive, not only because it shows the care with which the large station is studied, but because many of the items can be applied to the small plant at a nominal cost.

The sheet contains space for itemized totals by the month and for the year for fuel, water, oil and waste, etc., labor and material costs by months, with repairs upon major equipment units, kilowatt-hour essential costs, and the cost of coal per ton in the bunker. These items are supplemented by average monthly barometer readings, average vacuum, steam pressure and superheat at the throttle. Going deeper the sheet shows for each month and for the year the total kilowatt-hours output of each generating unit and of the station as a whole, the hours each unit was operated and the maximum load carried by each unit, as well as the station peaks. To complete the record, the summary shows the number of boiler hours, steaming, banked and lighted. The load factor is figured in two ways: First, by dividing the average load by the average maximum, and, second, by dividing the average by the maximum. The last item is of great value as it shows the relation between the demand upon the equipment for regular service and the equipment which must be carried to meet extreme calls upon the station for service.

Data of the foregoing character represent but little work when merely transcribed from daily log sheets, and those which require averaging are easily procured if carried forward from day to day; if left until the end of a month the task is likely to be burdensome. From the operating standpoint, the value of being able to see all the "high spots" by the month and for a year at a time need not be emphasized. The more these side lights are heeded, the better. Daily log sheets are essential to proper service, but summaries of plant operation extending over substantial periods are important aids to its real behavior and many irregularities are smoothed out or may start an inquiry of ultimate benefit. In the course of a year, every station passes through a complete long cycle of performance, a record of which is the best means of analysis available to the engineer.

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A Mistake Avoided

Years ago a condensing engine was (and in England to a large extent, still is) considered the only kind to install, because it is the most economical of steam. Then engineers came to appreciate that under certain conditions an engine is a first-rate reducing valve and the power it generates really a bonus, if low-pressure steam is required anyhow. Condensers, where they belong, are among the most important parts of plant equipments, but they are decidedly out of place in any plant that has use for all of its exhaust steam; such a plant is that of Reid, Murdoch & Co., described on other pages of this issue.

It is enlightening to follow the reasoning as set forth in the article referred to for not installing condensers. If all consulting engineers would use as much sense in analyzing the requirements of their clients before they put in unwarranted equipment, there would be more satisfaction all around. Incidentally, it would be a mighty good thing in the end for the manufacturers of the equipment omitted under such conditions. Fruitful soil is the only kind worth cultivating.

⁂

Engineering Salesmen

The foreword this week holds out two directions in which an operating engineer may hope to progress. One is quite obvious; advancing to a position of greater responsibility in the plant where he is engaged, as the superintendency of the works. Not so common is the other, that of salesman for the manufacturer of some line of equipment that he has been handling. Probably, it will come to many operating men as a new thought that there is a future for them in the selling field.

This idea appeals to us, and for some reasons besides those cited by the author of the foreword. As he says, we have a tendency to put confidence in the engineering salesman who shows a knowledge of his product in use. He is expected to be versed in the excellence of his goods so far as its manufacture is concerned and the material entering into it, but it is seldom that he can speak from experience as to its performance in operation. What he knows about what it does is usually second-hand knowledge picked up from his customers.

It has been the habit of manufacturers to recruit their selling force from the ranks of those who have the selling knack—and this, all too often, is based on the possession of a personality that wins friends, or a gift of persuasive speech. Not to discount these qualities, for they are highly important in any salesman, we maintain that they should be secondary and not primary considerations where the goods to be sold are of a nature such that the average individual cannot understand all that they involve in a short acquaintance with them. Any good salesman from his general knowledge, may quickly come to appreciate what distinguishes the good from the bad in cloth, or groceries, or a thousand other common commodities. Not so with anything so complicated as a piece of machinery, or even lubricating oils or fuel. Actual handling of these in use gives a man the customer's point of view as nothing else can. Where he can go to the prospective buyer forearmed with a knowledge of what his difficulties have been and how they may be overcome, the salesman's chances of a cordial reception are sure to be vastly increased.

Just as surely as the time has passed when the salesman needed to be a good mixer and stand treat generously to get orders, just so surely is the practice dying out of engaging men for their ability in the use of words. There is no denying the psychological effect, akin to hypnotism in some cases, of a flow of language that can sweep away doubts. This may make a first sale, but when the salesman has departed the goods must stand on their merits. If the buyer has been persuaded to take something ill-adapted to his needs, more harm than good has been done.

Let the next salesman who comes be a real engineering salesman. He can explain why the last trial was a failure and how to use his wares with success; thus a permanent user has been acquired. It goes without saying that the product sold must be deserving, but, given a worthy line and a salesman who is expert in the use of it, then the mere spellbinder has no chance.

Speed the time when more real engineers become engineering salesmen!

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That likeable character, Chief Teller, who figures in the Will Quizz, Jr., articles, has been discovered in real life. Read the letter "When Ignorance is Folly," on page 864, and you will find that the writer once worked under such a chief and is now that kind of a one himself. "May their tribe increase."

⁂

The highly commendable action of the Swedish government in making an appropriation whereby Swedish engineers may be enabled to visit the Panama-Pacific Exposition, could be profitably imitated by other nations. The engineering congress alone has aroused the interest of forty-two countries, and will be of broad educational value. The trip would also afford the visiting engineers an opportunity to visit the great industrial works in this country.

Correspondence

Settling Trays

The writer has obtained good results by the use of settling trays inside of return-tubular boilers. They are especially good in sections of the country where the water is muddy. One tray hung near the water line, with the feed pipe extended so as to empty into it, will arrest a large part of the solids. A tray suspended below the tubes from the through stays or supported from the bottom will also catch that sediment which would otherwise settle on the fire sheets, for the reason that the current of circulation is upward at the sides of the boiler and downward in the center.

F. W. Schneider.

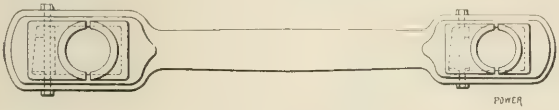
Clay Center, Ohio.

* * *

Bronze- vs. Babbitt-Lined Brass Boxes

Last summer I worked in a power plant which was undergoing a general overhauling. The care of the machinery is equally divided among the engineers and each is held responsible for the units allotted to him.

While the machinery is in operation the engineer on duty keeps it in service as long as he sees fit, and in cases of emergency, he is allowed to make minor repairs, which he enters on the daily report sheet. This rule works well as one man cannot blame the other for tampering with his machines, and it also enables the management to place the responsibility where it belongs.



Type of Rod

Shortly before one of the engines was taken out of service for general repairs, the crankpin box got hot and melted the babbitt metal just enough to fill the oil grooves and allow the brasses to come together. The engineer took the brasses down, cleared the oil grooves and replaced them, but without filing a clearance because new brasses were to be put on soon.

The new set was of a bronze composition, with babbitt buttons equally distributed over the bearing surfaces. The engineer objected to them. He said that the bronze boxes would get hot and ruin the crankpin; they would always be a source of trouble. His superior, however, said he would take the responsibility and told him to put the brasses on.

When the repair work was completed and the engine put back into service, it ran for only a short time before the brasses got hot. They were taken down and refitted, but in two days they got hot again. The engine was then taken out of service for several days while the old brasses were being rebabbitted.

I wanted to ask the engineer why he did not chip the edges of each half of the old brasses for clearance and put a liner behind them. This would have raised the wedge and made the rod its original length.

The brasses contained one-fourth inch of babbitt metal when they came together and the only thing they needed was the above treatment. However, as it was against the rules to ask questions or take suggestions from anyone, I decided not to ask. The management claimed that the bronze boxes were those that the builder furnished with the engine, and that they ought to have been put on before; but why did they heat?

I know of brass boxes that are in service, and of engineers who will not have anything else. They keep them keyed up brass to brass, and go to the trouble of taking them down and filing off the edges every time it is necessary to key them up. This is good, as it decreases the wear between the brasses and the strap.

The sketch shows the type of stub end referred to. I would like to hear from some of the engineers who are running brass boxes on crankpins.

Robert P. Harris.

Washington, D. C.

* * *

Automatic Shutoff for Water Valve

As the engineer is not only responsible for his own work but also for that of others, it is up to him to devise ways of eliminating the risk of forgetfulness on their part during his absence. The more extensive the plant, the greater the possibility that something may be forgotten.

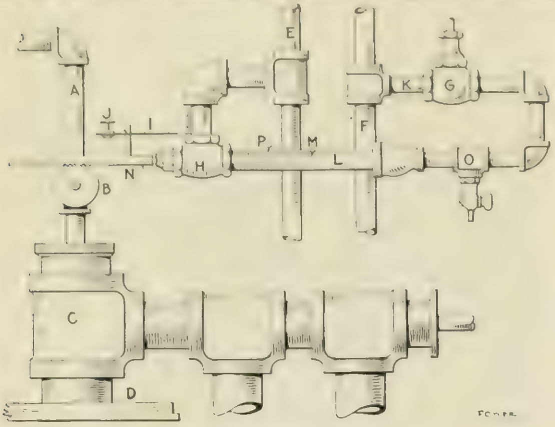
When the new wing of a certain trade school was erected with the basement one story lower than that of the main building the vacuum pump for the heating system had to be placed over 200 ft. from the engine room. It was necessary to use a jet of cooling water in the return to the pump.

It was a common occurrence for the night man to forget to close this water valve after shutting off the steam in the engine room. Then the whole heating system would be filled with water, causing leaks and a delay in heating the building in the morning. To avoid this nuisance and to make the system entirely automatic, the following device was attached to shut off the water when the steam was off.

To a $\frac{3}{4}$-in. angle-valve body *H* with the stem removed there was screwed a 6-in. piece of $\frac{3}{4}$-in. brass pipe *L* for a cylinder. A piston *M* was fitted in this pipe and attached to a $\frac{3}{8}$-in. steel rod *N* having a toothed rack several inches long, which meshed with the gear *B*. This gear replaced the handwheel of the valve on the cooling water pipe *A*. From the side of the valve body *H* a pipe was attached to the exhaust pipe *E* of the pump, so that any steam leakage past the piston would go into the heating system.

Back of the piston *M* there is a spring *P* of the proper tension to resist about 80 lb. steam pressure. A small pipe *K* is led from the pump steam-supply pipe *F* to a reducing coupling on the cylinder *L*. In this pipe there is a valve *G* and a cock *O* for cutting the device out of use. The amount of opening of the cooling-water valve is governed by the pin on rack *N* coming in contact with the stop *J*, which may be adjusted to the requirements for outside temperatures.

The operation is as follows: When the steam is turned on slowly in the engine room and the pressure reaches 15 or 20 lb., the vacuum pump starts. By the time the steam pressure in the pipe *F* is high enough to compress the spring, the returns will be hot and ready for the cooling jet.



Piping Arrangement

The pressure on the piston *M* compresses the spring *P* operating the rack *N*, and gear *B* opening the cooling-water valve, in which position it remains as long as the steam is on.

In shutting down, the spring will close the valve before the vacuum pump stops, thereby allowing the system to be cleared of water. It is not necessary for the engineer to make a trip to the pump pit to operate this valve, and it is impossible to open the valve or leave it open when the steam is shut off.

W. E. Seward.

Worcester, Mass.

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Oil in the Clutch

An induction motor which starts under load, on split phase, has a clutch which automatically engages with the shaft at speeds exceeding a certain predetermined value. The speed at which the clutch throws in and starts the shaft depends upon the adjustment of a spring against which centrifugal force acts. If the tension of this spring is too weak, the clutch will operate too soon, with the result that the drag due to the load will slow down the armature. On the other hand, all spring tension above that required will work against centrifugal force and decrease the force with which the core grips the shaft at synchronous speed. In any event, oil in the clutch will render it inoperative for sustaining appreciable loads.

An operator claimed that his motor heated and that it was not big enough for the work. Inspection showed that the whole motor, including the clutch members, was saturated with oil and that all of the heat came from slipping of the clutch on account of the oil. On disassembling the motor and giving all parts a gasoline bath, operation became normal. The oil in the motor was there as a result of carelessness in putting oil into the bearing on the clutch end.

J. C. Horton.

Schenectady, N. Y.

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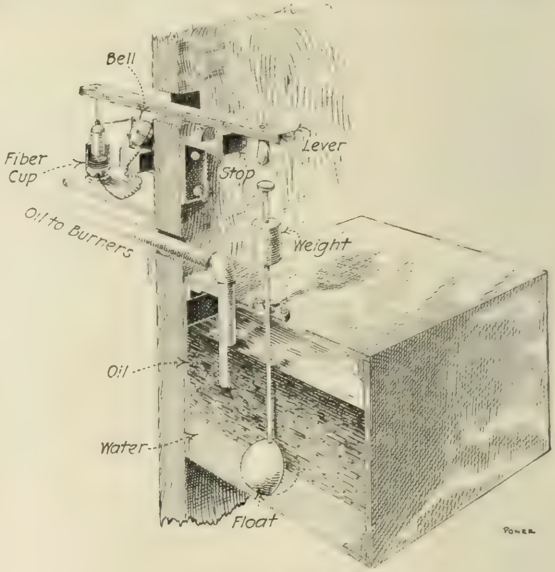
Protective Apparatus in Power Plants

Interruptions of service supplied from large power stations are so far-reaching in effect that it is most essential to safeguard against oversights and errors by operators and station attendants. In stations depending on liquid fuel for the boilers there is always the danger of water held in suspension in the oil settling in the bottom of the auxiliary oil tanks and accumulating sufficiently to get into the oil lines and burners, thereby putting out the fires and resulting in a loss of steam pressure until such time as the pipe lines may be drained and refilled with oil.

The illustration shows a novel device for detecting the presence of water in oil tanks. It has been tried out and found to operate successfully in a large steam-generating station where it is the aim to reduce service interruptions to a minimum.

The device consists of a float, the adjustment of which depends on the difference in specific gravities of oil and water, and an electric bell so connected that when the water accumulates to a certain depth in the bottom of the oil tank the float closes a contact in the bell circuit and rings an alarm.



High-Water Alarm

The float is weighted down just enough to overcome the buoyancy of the oil and to float in water, the water being heavier than oil. The amount of weight necessary to adjust the float is determined by experiment.

To insure perfect contact, and to guard against the ignition of gas which may accumulate over the oil tank, making and breaking of the electric alarm circuit is done in a fiber cup. In the bottom of the cup is a small amount of mercury in contact with one electrode, the other being a movable weight in the fiber cup counterbalanced on the end of a lever which is mounted on a knife-edge support.

The mercury is covered with oil to prevent sparking when the electric circuit is closed or opened. There is also a small fiber insulator on the end of the float rod to prevent sparking when the float rod comes in contact with the lever which operates the contact maker. This is necessary in the event of grounds developing in the electric circuit.

The small stop between the knife-edge support and the end of the lever adjacent to the float rod holds the lever in a definite position when the weight in the fiber cup is not making contact with the mercury, the counterbalance weight being just heavy enough to hold the lever down against the stop.

The object of this device is to notify firemen of the presence of water in fuel-oil tanks, so that it may be pumped out before it accumulates enough in depth to get into the burner lines.

J. M. LONG.

Redondo Beach, Calif.

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Hot Feed Water Caused Pump Trouble

In reference to H. C. Wight's trouble with hot feed water, mentioned in the issue of Mar. 10, I do not see why it was necessary to remove a shelf from the heater, or to pass a part of the exhaust steam to the atmosphere.

All the changes needed in such a case would be to put a tee in the suction line, close to the pump, and connect a pipe about 10 ft. high to act as a vapor column. Then the pressure would be equalized and the feed water could be heated up to about the boiling point.

ANDREW YORKE.

Hosmer, B. C., Canada.

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Lubricating Engine Bearings*

For bearings having a moderately high speed, with the oil fed into the bearing under perssure, the most satisfactory method of distribution is to run a straight groove to within a short distance of each end of the bearing. The pressure and revolving shaft will then keep up the continuous film. On heavy reciprocating sets having necks 20x36 in., with four-part bearing, I doubt if Mr. Farnsworth can find one that is not grooved.

In a slow-speed reciprocating engine the oil grooves act not only as distributers but as small feed reservoirs. Grooves have another good point, they catch and hold dirt which would cause cutting. Crankpins, if they receive a continuous supply of oil are not hard to lubricate as the action of the pin under fair pressure tends to help distribute the oil due to centrifugal force.

There are bearings, however, which will surely give trouble if they are not grooved, a case in point being a De Laval single-stage turbine wheel with drop lubricators.

I am not quite clear upon one passage in Mr. Farnsworth's letter, "100-lb. bearing pressure." Does he mean the weight of the shaft and wheel referred to the bearing area or the combined weight when loaded? If the latter, I must say that I have never yet found one having such liberal bearing surface. The bearing often neglected is the crosshead pin, which should undoubtedly be fitted with a self-feeding grease cup.

E. R. PEARCE.

Rochdale, England.

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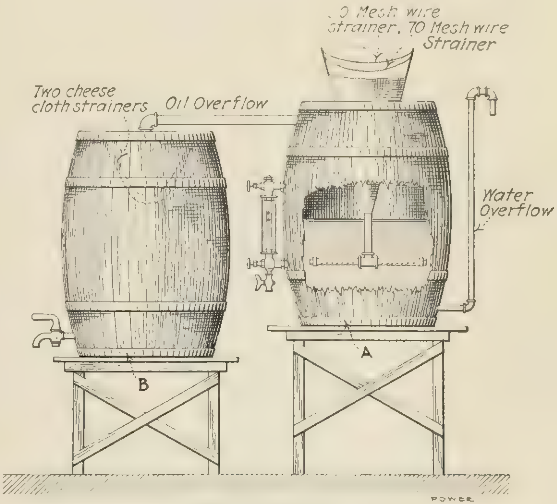
Oil Reclaiming and Filtering

The sketch shows a method that I have used to reclaim and filter waste oil. The barrel *A* is used as a separator and *B* as a strainer and receptacle. A ½-in. pipe is screwed into the barrel near the bottom, and fitted up so that the upper end is as high as the top. It is inclined enough for the water to overflow while the oil is overflowing into barrel *B*. A funnel into which the oil is emptied is soldered to a ¾-in. pipe, which extends nearly to the bottom of the barrel, and is fitted with a perforated pipe, as shown. The funnel has a 50- and 70-mesh wire strainer, through which the oil is poured. The barrel is kept about half filled with water. In barrel *B* a hole is cut in one head and two cheesecloth bag strainers are either made on hoops or tacked to the head, as shown.


50 Mesh wire strainer, 70 Mesh wire Strainer
Two cheese cloth strainers
Oil Overflow
Water Overflow
A
B
POWER

RECLAIMING OIL

If the water in the separator is kept near the boiling point, the oil will lose nearly all of the solid gritty substance, and the cheesecloth strainers will collect and hold anything that would injure the bearings. The oil collected is of several different grades. It is not safe to use it on a high-speed shaft, although it can be used on shafts and bearings where a high-grade oil is unnecessary.

GROVER C. HOPKINS.

East Pittsburgh, Penn.

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Delivery of Pump Increased by Throttling the Suction

The hotwell overflow from a 150-hp. engine at one time discharged through about 50 ft. of 4-in. cast-iron piping to a cooling pond (or "lodge," as we call them in Lancashire), but owing to extending the building the lodge has been covered over and is now of no use for cooling purposes.

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*See "Power," Jan. 20, 1914, page 104, and Apr. 7, page 493.

The original pipe to the lodge is still in place, but at present the water is all supposed to be delivered by a centrifugal pump to the roof, where a number of cooling troughs have been arranged. The pump delivered water intermittently for about 3 min. and then stopped altogether for about an equal period.

At the air pump it was seen that the level of water in the hotwell gradually rose and fell, the period of fluctuation corresponding with that of the discharge from the pump.

What was happening became evident. The centrifugal pump was capable of taking more water than the air pump was delivering, and consequently lowered the water in the hotwell until it drew air. For the pump to get rid of this air occupied a matter of about 3 min., during which time the water rose in the hotwell and flowed to the lodge through the old overflow pipe.

The remedy was to restrict the centrifugal pump until it just maintained a steady level of water in the hotwell. This was done by means of a valve on the suction, with the result that the pump now maintains a steady discharge and delivers about three times as much water as previously.

C. K. Williams.

Manchester, England.

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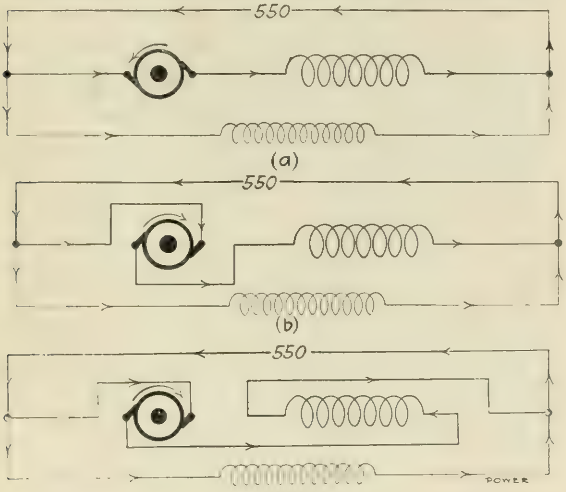
Reversing Rotation of Interpole Motor

Assuming that the interpole field coils and the armature of an interpole motor have the right relative connections for a given direction of rotation, if it is desired to reverse the direction of rotation of the armature, it may be done either by reversing the field or by reversing the armature and interpole field considered as a single unit. In a case in mind, the shunt-wound interpole motor as it came from the makers was connected to run in a clockwise direction. It became necessary, however, that it be run counterclockwise.



Original, Wrong and Right Connections

In the accompanying diagrams *a* indicates the original connection and *b* the change made by the operator to reverse the direction of rotation. He reversed the armature connection and did not reverse the connection of the interpoles. The result was to change the correct magnetic relations of the armature and interpole magnetisms so that the brushes sparked viciously at starting, although the sparking disappeared after the motor came up to speed because the motor was running comparatively light and the interpole current was not large enough to have an appreciable effect.

The further change that was made to restore the correct armature-interpole relation is shown at *c*. Here, both the armature and the interpoles have been reversed separately, because it was inconvenient to reverse them as a single unit.

J. A. Horton.

Schenectady, N. Y.

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When Ignorance Is Folly

The editorial in Power, Apr. 21, headed as above, mentions a subject which should interest engineers, that of asking questions. There seems to be a general antipathy to asking questions from one another, which is not conducive to an increase of practical knowledge of the business. Why this is so is hard to explain, as more real practical experience can be gained from practical talks than in any way except from actual practice.

Hardly a difficulty arises that somebody has not met sometime or other, and by inquiring among his friends a man may nearly always find a solution.

Some engineers are loath to give information to others, which should not be. I well remember, when I was young in the business, of a chief saying to me, "Young fellow, anything you want to know, come and ask me and I will tell you, if I know it, as I do not consider this business any secret, and if I do not know I will find out for you and then it will be information for me as well as you."

I never forgot that and always told it to my own assistants and subordinates. I say here that the man in charge of a plant, whose assistants come to him for information, will be surprised to find how many little things are brought to him upon which he lacks a thorough knowledge. The practice of explaining things in detail will broaden his own experience as well.

Further, the engineer who practices answering his subordinates' questions will find himself much better fitted to answer questions fully and to the point when put to him by his superior.

Brooklyn, N. Y.

William N. Wing.

⁂

Electrifying Furnace Air

In cases where mechanical draft is used, it would seem that a much greater efficiency could be obtained, and the smoke trouble reduced, by electrifying the air before it goes into the blower. This would cause the air to become ozone; that is, each atom of oxygen would double up, as it were, and when coming in contact with the fire it would more energetically combine than does the ordinary air—would act something like air highly charged with oxygen. Ozonizers are commercial apparatus, they do not use up much power, and their application in this case would not require a great deal of ingenuity.

A. P. Connor.

Washington, D. C.

Inquiries of General Interest

Detecting Fracture in Stay-Bolt—How can it be ascertained whether a stay-bolt staying flat surfaces is fractured?

A. D. J.

By drilling a small hole in the end of the stay-bolt a fracture will be revealed by the escape of water and steam.

Object of Condenser—How does a condenser increase the power which an engine can develop?

C. F.

By removing back pressure and thereby increasing the mean effective pressure acting on the piston.

Rate of Heat Transmission in Heaters—What is the rate of transmission of heat in tubes of feed-water heaters?

C. L. H.

The rate varies with the size of the tubes and the velocity of the water passing through the tubes. For 1¼-in. smooth tubes it increases rapidly from about 185 B.t.u. per sq.ft. per hour per degree difference of temperature for a velocity of about 22 ft. per min. to about 580 B.t.u. for a velocity of 115 ft. per min.

Height for Gage-Cocks—At what height should gage-cocks be placed on a horizontal return-tubular boiler?

J. B. P.

The lowest gage-cock should be not less than 2¼ in. above the highest point of the upper row of tubes when the boiler is set, and on a power boiler having a water glass, there should be three or more gage-cocks within the range of the visible length of the water glass.

Pulsation of Steam Pipe—How can pulsations in a steam line to an engine be prevented?

A. H. S.

By placing a receiver in the line near the engine. It should be large enough to prevent the intermittent discharges of steam to the engine from materially affecting the uniformity of the receiver pressure when sustained by a practically uniform rate of flow in the steam pipe.

Operation of Scum Blowoff—What is the best way to operate a funnel-mouthed surface blowoff, which is placed near the rear head in a return-tubular boiler?

W. D.

The best method is to open the blowoff for a few seconds at intervals of 15 to 20 min. or oftener, rather than to open it for a longer period at longer intervals. Observation of the character of the discharge is the only guide for determining the frequency of blowing off.

Acetylene Gas for Internal-Combustion Engines—Has acetylene gas been successfully employed for running internal-combustion engines in place of gasoline, and if so how does its use compare in cost with that of gasoline?

H. S.

Employment of acetylene for internal-combustion engines has hardly advanced beyond experiment, the leading obstacles to its adaptation in place of gasoline being that it cannot be used in engines employing high compression as spontaneous combustion takes place at much lower pressures, and its use is attended by a disagreeable odor. For the same power output the cost of acetylene is about 2½ times that of gasoline.

Clearance Affected by Keying Rod—What effect has keying up a solid-end connecting-rod on clearance in the cylinder of an engine?

H. G.

When the keying tends to lengthen the distance from the center of the crosshead pin to the center of the crank-pin, the clearance will be increased on the crank end and decreased on the head end of the cylinder; and when it tends to shorten the aforementioned distance the clearance will be increased on the head end and decreased on the crank end of the cylinder. In some forms of connecting-rods the keying is so arranged that the wedging action of keying at one end tends to shorten and that of the other end to lengthen the distance between centers, so that keying one end counteracts the effect which the other has on the clearance.

Head Pumped Against—If water from a surface condenser carrying 23.5 vacuum is delivered by gravity with a drop of 3 ft. to a centrifugal pump which discharges at an elevation of 22 ft., what is the equivalent head which the pump works against?

F. C.

The head pumped against would consist of the net head of water plus the head equivalent to the difference between the pressure in the condenser and the pressure of the atmosphere. The net head of water being

$$22 - 3 = 19 \text{ ft.},$$

or

$$19 \times 0.433 = 8.227 \text{ lb. per sq.in.};$$

and as 23.5 in. of vacuum on the condenser signifies that the amount which atmospheric pressure is above the pressure of the condenser is

$$23.5 \times 0.491 \text{ or } 11.539 \text{ lb. per sq.in.},$$

the total pressure pumped against is, therefore,

$$8.227 + 11.593 = 19.766 \text{ lb. per sq.in., which is}$$

equivalent to

$$19.766 \times 2.309 \text{ or } 45.6 \text{ ft. head.}$$

Water Evaporated with Overload—With the temperature of the feed water 150 deg. F., how many pounds of water would be evaporated per hour into steam at 100 lb. pressure by a 600-hp. boiler overloaded 25 per cent.?

T. F. C.

To raise one pound of water from 32 deg. F. to steam at 100-lb. boiler pressure would require 1188.8 B.t.u., and as a pound of feed water at 150 deg. F. would contain about

$$150 - 32 = 118 \text{ B.t.u. above 32 deg. F.}$$

then each pound of feed water at 150 deg F. raised into steam at 100 lb. boiler pressure would require about

$$1188.8 - 118 = 1070.8 \text{ B.t.u.}$$

A boiler horsepower is equivalent to the evaporation of 34½ lb. of water per hour from and at 212 deg. F., requiring 33,479 B.t.u., and 600 boiler horsepower would be equivalent to

$$33{,}479 \times 600 = 20{,}087{,}400 \text{ Btu. per hr.}$$

Since each pound of water, under the conditions stated, would receive 1070.8 B.t.u. then 600 boiler horsepower would require the evaporation of

$$\frac{20{,}087{,}400}{1070.8} = 18{,}759 \text{ lb.}$$

of water per hour, and with 25 per cent. overload the evaporation should be

$$18{,}759 \times 1.25 = 23{,}448.75 \text{ lb.}$$

of water per hour.

Relative Loss of Pressure Using 2-In. or 3-In. Supply Pipe—The supply to a hot-water tank is to be taken from an open house tank 175 ft. above the hot-water tank by a 2-in. supply line. What will be the pressure in the hot-water tank, and what will be the relative loss of pressure if the size of the supply is made 3 in. instead of 2 in.?

M. S.

The static or standing pressure would be

$$175 \times 0.433 = 75.8 \text{ lb. per sq.in.}$$

with any size of supply pipe, but when water is drawn from the hot-water tank the pressure will be reduced lower the smaller the supply pipe, because more of the pressure from the house tank will be spent in overcoming friction in the supply pipe. The loss by friction in any case will depend on the length of the pipe, the number of elbows and fittings and their roughness. These conditions being the same, the loss of pressure varies as the square of the velocity of the discharge The discharges for the same velocity would be in the ratio of $2^2:3^2$, or as 4 to 9, hence for the same discharge the velocity in the 3-in pipe would be $^4/_9$ the velocity required in the 2-in pipe, and as the loss of pressure would be practically in proportion to the squares of the velocities, then delivering the same quantity per second

$$\frac{\text{loss in 2-in pipe}}{\text{loss in 3-in pipe}} = \frac{1^2}{(\frac{4}{9})^2} = \frac{1}{5}$$

or about one-fifth as much pressure will be lost in pipe friction when using a 3-in. pipe as when using a 2-in. pipe.

Engineers' Study Course

Elementary Mechanics—XIII

LAST LESSON'S ANSWERS

51. In this case the distance A (see Fig. 45) is 3 in.; the distance B is 48 in., and the effort P is 75 lb. Therefore,

$$W = \frac{P \times B}{A} = \frac{75 \times 48}{3} = 1200\ lb.$$

52. The wheelbarrow is a lever of the second class; hence in Fig. 46 the distance A is 12 in., the distance B is $(40 + 12) = 52$ in., and the effort $P = 60$ lb. Hence.

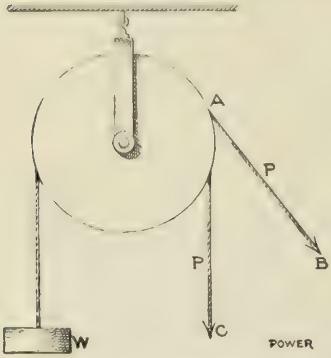

FIG. 50

$$W = \frac{P \times B}{A} = \frac{60 \times 52}{12} = 260\ lb.$$

which would be the load that could be balanced by an effort of 60 lb.

53. The pressure of the wheel on the ground would be the reaction R of the fulcrum as shown in Fig. 46, or $R = (W - P) = (260 - 60) = 200$ lb.

54. The total pressure of the steam on the valve equals

$$0.7854 \times 4^2 \times 80 = 1005 \text{ lb.}$$

The distance L may be found from equation 18, thus,

$$w \times C + w_1 \times l + W \times L = P \times C$$

where $w = 10$ lb., $C = 4\frac{1}{2}$ in., $w_1 = 25$ lb., $l = 15$ in., $W = 100$ lb. and $P = 1005$ lb. Hence.

$$W \times L = P \times C - w \times C - w_1 \times l$$

or

$$L = \frac{P \times C - w \times C - w_1 \times l}{W}$$

$$= \frac{1005 \times 4.5 - 10 \times 4.5 - 25 \times 15}{100} = 41\ in.$$

therefore, to balance the steam pressure of 80 lb. per sq. in., the ball W weighing 100 lb. would be placed 41 in. from the fulcrum A.

55. Equation (19) may be used in the solution of this problem. Thus,

$$P = \frac{W \times R}{L}$$

or

$$W = \frac{P \times L}{R} = \frac{80 \times 18}{3} = 480\ lb.$$

It might be well to note at this point that the force of 80 lb. would not raise the weight of 480 lb. until the weight was set in motion by a force sufficient to overcome its inertia.

PULLEYS

The *pulley* is a machine operated by a flexible cord passing over a *grooved wheel,* which is mounted in a frame called the *block.* Pulleys are either *fixed* or *movable,* depending upon whether they are held in a fixed position or move with the given load. In this discussion, both the weight of the pulley and of the rope will be neglected as these are usually very small compared with the loads handled. Further, the friction at the bearings will be neglected, and it will be assumed that *the pull in a flexible cord or rope is uniform throughout its entire length.*

There are three systems of pulleys, but only the one in common use around the power plant will be discussed. A single fixed pulley has no mechanical advantage and can only change the direction of the pull on a given weight. Thus in Fig. 50, the effort P and the weight W are equal and this relation holds true irrespective of whether the pull P is vertical as shown by the line AC, or inclined as shown by the line AB.

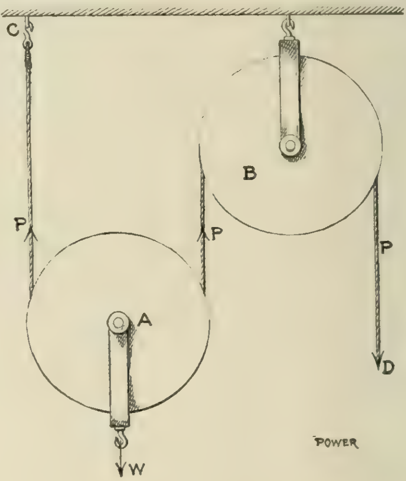

FIG. 51.

A single movable pulley A and a fixed pulley B may be used to considerable advantage. In Fig. 51, the rope is attached at the point C, passes over the movable pulley A and thence over the fixed pulley B to a point where the pull P is applied. The tension throughout the entire rope is P pounds. Therefore, the total upward pull on the pulley A is $2P$ pounds, and for equilibrium $2P$ must equal W or $P = \frac{W}{2}$, which means that a force of 50 lb. applied at the point D is capable of balancing a force of 100 lb. at the point A.

When a pulley is made up of a number of wheels mounted on a common axis, each wheel is called a *"sheave."* Usually, there will be one movable block and one fixed block, each consisting of the same number of sheaves. A continuous rope passes over all the sheaves as shown in Fig. 52. The rope is secured to the bottom of the fixed pulley, from where it passes to the first sheave on the movable block, thence to the fixed pulley and so alternates until it finally leaves the last sheave on the fixed pulley, and is conducted to the point where the effort P is applied. Thus, if there are three sheaves in the movable block, the total upward pull on the block will equal $6 \times P$, since the pull in the rope is assumed uniform throughout its entire length, and there are six ropes supporting the movable block.

Hence the total upward pull on the movable block in a system of pulleys of this kind will equal the number of ropes attached to, or passing over the movable block, times the effort P on the rope. If one end of the rope is attached to the movable block, the latter will contain one less sheave than the fixed block and the mechanical advantage will be less than that of the system shown in Fig. 52.

Another practical application of the principle of moments is in the *Weston Differential Pulley,* which consists of a fixed block containing two groved sheaves of slightly different diameters, and a single movable pulley which is also grooved so as to receive the links of a chain which passes around the sheaves as shown in Fig. 53. Any motion of the chain causes a positive motion of the sheaves as there can be no slipping of the chain on the sheaves. The relation between the effort P and the weight W may be determined as follows. In Fig. 53, let r be the radius of the smaller sheave on the fixed block and R_1 the radius of the larger sheave on the fixed block. Let P be the effort applied to the hoisting chain and W the weight to be balanced. It is evident that the pull in the chain passing over the movable sheave is $\frac{1}{2}W$ since there are practically two chains supporting the given weight. For equilibrium to exist, the algebraic sum of the moments of all the forces about the point O (which is the center of the fixed block) must equal zero. Thus,

$$P \times R + \tfrac{1}{2}W \times r - \tfrac{1}{2}W \times R = O$$

or

$$\tfrac{1}{2}W \times (R - r) = P \times R$$

hence,

$$W = 2\,P \times \frac{R}{(R - r)} \qquad (20)$$

The *mechanical advantage* of the differential pulley is

$$\frac{2\,R}{(R - r)}$$

By making R and r as near equal as possible, the weight W may be much greater than the effort P. The efficiency of this hoist and the relative distances moved by the weight and the effort will be discussed fully under the lesson on work and power which will come later in the course.

Study Questions

56. In Fig. 51, what weight W could be balanced by a man who exerts a pull of 80 lb. at the point D?

57. In a system of pulleys arranged as in Fig. 52, there are four sheaves on the movable block. If one end of the rope be attached to the fixed block, what weight W could be balanced by an effort of 100 lb. being applied at the free end of the rope?

58. In problem 57, assume the rope attached to the movable block. How many sheaves would be on the fixed block if there are four on the movable block? What weight W might be balanced by an effort of 100 lb. being applied at the free end of the rope?

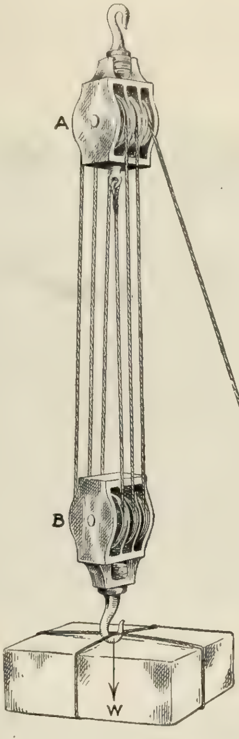

Fig. 52.

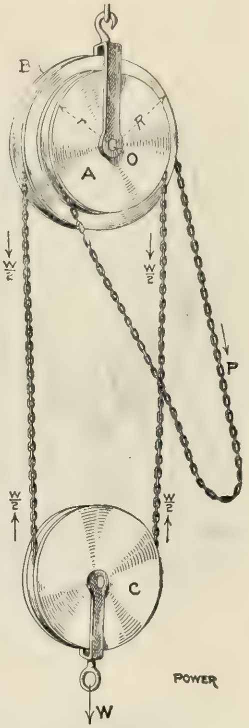

Fig. 53.

59. In problems 57 and 58 find the reactions on the hook supporting the fixed block.

60. In Fig. 53 if $R = 8$ in., $r = 7$ in., find the weight W that could be balanced by an effort of 100 lb. applied to the chain.

⁂

Electricity for Heat, and for all other services involving the use of energy, will be used in a new high school building at Rupert, Idaho, in the center of the Minidoka Irrigation Project. For the general heating apparatus, the common arrangement of hot-air pipes, etc., has been adhered to but the heat is furnished by a battery of electrical units, similar to those used in large ovens. Twenty 18-kw. units are to be installed in pairs, each pair having a separate control from a switchboard in the principal office. Current comes from the Project power house, 14 miles away, and the estimated cost of operation is placed at $1760 a year compared with coal supply at $1000 plus a fireman at $75 per month. The first cost of the electric system was $3000 less than the other. The equipment was planned by local electricians, with the assistance of the government engineers on the Project. In addition to the heating, a 10-hp. motor drives a ventilating fan and supplies power for the manual training department. An electric hot-water heater supplies the domestic science department, the shower baths, lavatories, etc. In the domestic science laboratory are individual electric stoves, an electric range, and various appliances. The electric lighting includes a small theater equipment for the school auditorium.

Baltimore Convention of the A. O. S. E.

The twenty-eighth annual convention of the American Order of Steam Engineers was held at Baltimore, Md., during the week commencing June 1, with the Rennert Hotel as headquarters. The attendance of delegates was unusually large. At the several sessions of the delegates many important matters conducive to the welfare of the organization were disposed of.

The main hall of the Fourth Regiment Armory was conveniently arranged and tastefully decorated for the use of the supplymen for their mechanical display. There were upward of ninety booths, and the exhibit attracted a good attendance throughout the week.

On Monday evening there was a combined gathering of the delegates and supplymen in the armory, when the formal opening of the exhibit took place. Mayor James H. Preston extended a warm welcome to the visitors, and was ably responded to by William Le Compte, past president of the Supplymen's Association. President George W. Goodwin of the Engineers, and President Fred L. Jahn of the Supplymen, also made appropriate addresses.

At one o'clock on Tuesday the company boarded special cars for an inspection of the sewage-disposal plant. Later in the afternoon at Liberty Park there was a crab feast, followed by a ball game between the Engineers and the Supplymen which resulted in a tie after a most interesting and exciting game. The supplymen gave an enjoyable entertainment at the exhibit hall on Wednesday evening.

The feature of the entertainment program was the steamboat ride on Thursday afternoon. The fireboat practice given by the crew of the tug "Deluge" was greatly enjoyed and, altogether, the day was a most pleasant one.

The election of officers for the supreme council resulted as follows:

J. William Pairent, chief; William R. Smith, first assistant chief; William A. Harding, recording engineer; Edward A. Reboul, corresponding engineer; Michael Helmstreit, Jr.,

Delegates at the Convention of the American Order of Steam Engineers, Baltimore, Md., June 1, 1914

A Group of the Supply Men at the A. O. S. E. Baltimore Convention treasurer engineer; J. H. Moudy, senior master mechanic; H. R. Dixon, junior master mechanic; H. R. Messer, inside sentinel; William Tyson, outside sentinel; L. J. C. Callaway, chaplain; L. G. Schlehner, trustee; D. B. Heilman, trustee; G. W. Goodwin, trustee. The executive committee are George R. Richardson, Clifford P. Williams and Franklin R. Moore.

The Supplymen's Association connected with the American Order of Steam Engineers elected the following officers: Harry E. Souder, president; Charles A. Wilhoft, vice-president; Hart Hill, secretary; John W. Armour, treasurer.

A. E. Smith was appointed director of exhibits.

THE EXHIBITORS

John B. Adt Co.
Albany Lubricating Co.
American Bitumastic Enamel Co.
Anchor Packing Co.
V. D. Anderson Co.
Ashton Valve Co.
Aumen Machinery Co.
Automatic Shaft Coupling Co.
Baltimore Belting Co.
Baltimore Electrical Co.
Baltimore Gas Light Co.
Baltimore Roofing & Asbestos Co.
Cyrus Borgener & Co.
Carey Machinery & Supply Co.
Lawford & McKim
Lee Electric Co.
John R. Livezey
Geo. W. Lord Co.
The Lunkenheimer Co.
Lutz Webster Engineering Co.
McLeod & Henry Co.
Robert McMeckan & Son
Maryland Casualty Co.
Maryland Council No. 1 A. O. S. E.
Morehead Mfg. Co.
National Flue Cleaner Co.
National Tube Co.
New York Belting & Packing Co.
Crane Co.
Crook, Kriess & Co.
Cumberland Coal Co.
Dearborn Chemical Co.
Diamond Power Specialty Co.
R. & J. Dick, Ltd.
Jos. Dixon Crucible Co.
Emerson & Morgan Co.
Engineering Supply Co.
Fairbanks Co.
France Metallic Packing Co.
Frick Co.
Frick Grate Bar Co.
Garlock Packing Co.
General Electric Co.
Gray Engineering Co.
Greene, Tweed & Co.
Griscom Russell Co.
Hawley Down Draft Furnace
Home Rubber Co.
E. F. Houghton & Co.
Paul B. Huyette Co.
International Boiler Cleaning Co.
Jenkins Bros.
H. W. Johns-Manville Co.
R. Lee Jones Coal Co.
T. P. Kelly & Co., Inc.
Keystone Lubricating Co.
Lagonda Mfg. Co.
Otis Elevator Co.
Peerless Rubber Mfg. Co.
Philadelphia Bourse
Philadelphia Grease Mfg. Co.
"Popular Engineer."
"Power."
Pratt & Cady Co.
Quaker City Rubber Co.
Reeves Cubberly Gasoline Engine Co.
Wm. C. Robinson Co.
E. J. Rooksby & Co.
Frank R. Small.
L. Sonneborn Sons, Inc.
Southern Electric Co.
Standard Electric & Elevator Co.
Wallace Stebbins & Son.
Strong, Carlisle & Hammond Co.
The Texas Co.
Geo. W. Walther & Co.
Wallace & Gale.
Watson & McDaniel Co.
Warren Webster & Co.
Wilson Maltman Electric Co.
Thos. C. Worley & Co.
Chas. Zies & Son.

The 1915 convention will be held in Atlantic City.

* * *

Annual Meeting of National Electric Light Association

With an attendance of approximately thirty-five hundred, the thirty-seventh convention of the National Electric Light Association at Philadelphia, June 1 to 5, proved one of the most successful in the history of the association. Much credit is due the Philadelphia Electric Co. for the way in which the local features of the program were carried out.

As customary, the first day was devoted to the registration of members, and in the evening a reception was held at the Bellevue-Stratford, the convention headquarters. The first general session was opened on Tuesday morning with an address by Mayor Blankenburg, of Philadelphia, who took as his theme "Light as a Factor in Civilization," pointing out how it not only added to the comforts of mankind, but was also a potent aid to police power.

PRESIDENT'S ADDRESS

Following the mayor, President McCall referred to the growth of the association, and stated that its membership now numbered over thirteen thousand. He also briefly reviewed the work of the various committees and touched upon the suggestion that a modification be made in the method of conducting the national convention, confining the meeting to a few representatives from geographical sections, these delegates to give consideration to broad policies only. The commercial and technical details would then be taken up by the state conventions. "Much might be said in favor of this change of policy," commented Mr. McCall, "and the change would no doubt be welcomed by those whose duty it has been to prepare for the holding of national conventions." No definite action was taken upon the suggestion, however.

As to governmental regulation, President McCall expressed the opinion that public-service commissions, which have now been established in a majority of the states, have led to a better understanding of the relations between the public and the utility companies. These commissions have, in general, wisely used the powers intrusted to them, and they have protected both the community and the company from hasty and ill-advised action which is often the outcome of political pressure.

SECRETARY'S REPORT

The secretary's report dealt principally with the work being carried out at the executive offices in New York, and with the publications of the association. This was followed by the report of the insurance expert, W. H. Blood, who spoke of the proposed revision of the National Electrical Code, with regard to constant potential pole lines of over 5000 volts and to refillable fuses.

REPORT ON PROGRESS

T. C. Martin's report on progress dealt with the general conditions of the electrical industry and was so full of interest and instructive statistics, that a rather obvious attempt to discredit the municipal plant may be passed over without further comment. Quoting from the recently published figures of the United States Census Bureau, it showed that there was in 1912 installed in central stations in this country about 5,000,000 hp. in steam turbines and steam engines, and 2,500,000 hp. in waterwheels; these figures are now exceeded. During the past year the Commonwealth Edison Co., of Chicago, showed a gain of nearly 19 per cent. in its output over that of the preceding year; the Philadelphia Electric Co., 25 per cent.; the New York, Boston and Brooklyn Edison companies, each about 11 per cent.; and the Niagara Falls Power Co. a gain of 9 per cent.

Relative to the pending national legislation regarding holding companies, Mr. Martin was of the opinion that whatever the objections to holding companies with reference to the control of competing interstate railroads or industrial enterprises, they can have little, if any, application to the electric-lighting or electric-railway field. "Such bodies, in the electrical field," he said, "are not organized to stifle competition, but to give the benefit of expert aid in engineering and finance to scattered parts, whose existence otherwise often would not be warranted." Statistics were quoted to show that out of 4774 plants in towns of over 1000 population, 29 per cent. have syndicate affiliations, 48 per cent. are independent, and 23 per cent. are municipal.

During the past year public-service commissions were created in ten more states, including Illinois and Pennsylvania; the principal provisions of the public-service laws in these two states being cited.

The secretary's report also gave a complete description of the new 201st St. station of the United Electric Co. in New York.

Touching upon hydro-electric progress, space was devoted to a review of the work and recommendations of the conservation congress held in Washington last December. While a number of hydro-electric plants were completed and put in operation in this country during the past year, no radical departures from previous practice were noted. Descriptions of several of these plants were contained in the report and attention was called to the increasing use of outdoor substations. In Europe, however, several important developments have been projected, notably two plants on the upper Rhone, one of 150,000 hp. and the other of 120,000 hp. These will transmit electricity to Paris at 150,000 volts. Also, the Italian Parliament has recently passed an act authorizing the construction of a 150,000-hp. hydro-electric development at Calabria, in southern Italy.

TECHNICAL SESSIONS

At the first technical session the committee on meters rendered its report, which was followed by that of the committee on grounding secondaries. This showed that many of the smaller companies are not paying as much attention to grounding secondaries as they should; that many are grounding to driven pipes and buried cones, neither of which methods is allowed by the code. The report emphasized the importance of grounding to water pipes, and pointed out that this is not detrimental to the piping.

Reporting on "Electrical measurements," Dr. A. E. Kennelly gave a brief outline of the course of events which led to the adoption of an international standard of electrical conductivity for copper by the International Electrotechnical Commission in Berlin last September.

Dr. C. P. Steinmetz was most optimistic as to the future for the electrical vehicle in that it would be a means to greatly improving the central station load factor. Citing the history of the bicycle, he predicted that during the next ten years the automobile would have run its course as a vehicle of pleasure and would be used almost exclusively for business. In this capacity the demand would be for moderate speeds and simplicity of operation with minimum attendance. Here, he contended, the electric vehicle would come to its own, and the charging of the batteries during off-peak hours would provide a most profitable business for the central station. As these machines rarely use up the full charge during the day, he believed that the central station could ultimately take over such service at a fixed charge of, say $10 per month.

The second technical session was held Wednesday morning, the first report being that of the committee on electrical apparatus, which was presented by L. L. Elden. The more recent types of converting and generating apparatus, air-cooling devices, switchboard equipment and protective devices were taken up, and reference was made to the use of synchronous condensers for voltage regulation of high-tension lines.

"Temperature and Its Effects on the Power Capacity of Electrical Apparatus"* was the subject of a most interesting paper by F. D. Newbury. This presented the information at present available on the heat and temperature conditions within large alternating-current generators, the safe temperature limits of the various insulating materials in common use, and the significance of temperature measurements by different methods.

Underground construction was treated by the committee of which Philip Torchio was chairman. Operating data on high-tension cables were submitted by member companies, a marked difference being shown in the thickness of insulation used for cables of relatively low voltages, but greater uniformity for high-voltage cables. The maximum allowable loading from different companies gave temperatures varying from 90 to 150 degrees Fahrenheit for the lead sheath, and tests made to supplement this information showed the temperature of the conductor to be as much as 75 degrees higher than that of the sheath. The committee stated that its efforts to discover an inexpensive system of underground distribution had been futile.

The report on overhead line construction was next presented by Thomas Sproule, of Philadelphia, and completed the program of that session.

PUBLIC POLICY

Mr. Insull, in reporting for the public policy committee, expressed much the same views as did President McCall regarding public-service commissions, but further voiced the seriousness of any contemplated national legislation designed to limit the activities of generating companies. In this connection, he urged that missionary work be done in educating congressmen and senators on the economics of the business as a natural but regulated monopoly, so that there would be no tendency to check electrical interstate business through misdirected anti-trust legislation. Commenting on prosperity, he declared that hard times did not seem to affect the electrical business, which was attributable to the electrical companies not yet having developed their territories to the saturation point.

ANNIVERSARY EXERCISES

After Mr. Insull's remarks the Wednesday evening meeting was devoted to exercises celebrating the 30th anniversary of the First International Electrical Conference and Exhibition held at Philadelphia in 1884. Walton Clark, president of the Franklin Institute, presided and introduced as speakers a number of pioneers in the electrical industry, including Dr. Charles F. Brush, inventor of the arc-lighting system, F. J. Sprague, of electric-railway fame, and E. W. Rice, president of the General Electric Co. Thomas Edison was also present, but following his usual custom, did not make an address.

Mr. Rice spoke of having attended the Philadelphia conference, as a young man, and listened to such distinguished scientists as Kelvin, Preece, Thomson, Newcomb and Rowland. In 1884, he said, not a single trolley car was in existence, the highest potential employed was 2000 volts and the largest electrical generator was the Edison "Jumbo" machine, having a rating of 1200 sixteen-candlepower lamps. The electric motor was just coming into use and a few of small size were exhibited; the largest engine on exhibition was of less than 150 hp.

Brush, after relating some reminiscences of his early experiences in electric lighting, told of the first installation in Philadelphia, that of Wanamaker's store, which contained 20 arc lamps. One year later, 1879, the first electric street lights were placed in the public square at Cleveland.

Mr. Sprague spoke of his work in connection with the building of the first electric street-car line, in Richmond, Va., in 1887; also the electrification of the elevated railways in New York. He predicted the electrification of trunk-line railways, stating that this would be brought about by the greater centralization of power generation, the railroads finding it cheaper to purchase electricity from such sources than to generate it themselves.

THIRD TECHNICAL SESSION

The report on prime movers was divided into two sections, that on steam being presented by J. B. Klumpp, in the absence of Chairman I. E. Moultrop, and that on hydraulic matters by J. F. Vaughan.

Under the steam heading the following subjects were discussed: Cost of Steam Power Standby Service, Forced Draft for Peak Work, Emission of Smoke and Cinders, Burning Pulverized Coal, Under-Water Storage of Coal, Firebrick, Steam-Flow Meters, Surface Combustion, Condensers, Boiler Tubes, and Foreign Practice.

Under the first heading was described the practice at the Ashley Street station in St. Louis,* where the standby boilers are kept full of hot water at over 200 degrees by means of a hot-water circulating system. The amount of coal used for banking is about 5 per cent. of the total consumption of the station.

With regard to cinders, the report stated that there is practically no trouble from this source with natural draft, or where the difference in pressure through the fire is 1 in. or less. With forced draft, however, there is frequently a noticeable shower of cinders in the vicinity of the plant, particularly where coking coal is used. The best solution of this problem has been worked out by the New York Edison Co., in causing the gas to impinge against a wet baffle plate, from which it is deflected downward toward a trough of water, in which the cinders are caught.†

The committee did not consider under-water storage of coal as warranted generally, owing to the high cost of such storage as compared with the low insurance rate and the fact that well selected coal was fairly secure against taking fire. If it did, the pile would give a long warning of the tendency to heat.

Lap-welded charcoal-iron boiler tubes were formerly demanded by most steam users because they were not so likely to corrode as steel. Genuine charcoal iron, however, has become very scarce, and the demand for tubes has greatly increased; hence it is difficult to obtain the quality of tube desired. All tubes other than seamless must be welded, and, as in all welds there is a chance for imperfect workmanship, the open-hearth seamless steel tube is now being specified largely and is used with much success.

HYDRO-ELECTRIC SECTION

The papers presented on this subject were: "The Nature of Electrical Disturbances in Transmission Work," by D. B. Rushmore; "Data on Modern High-Voltage Transmission," by Selby Haar; and "Water-Power Plant Economics," by O. B. Coldwell. These were followed by an illustrated lecture by H. J. Lisberger on the plants and system of the Pacific Gas & Electric Co., in California.

Upon recommendation of the committee the hydroelectric section was disbanded, this work to be carried on in the future by a hydro-electric committee.

Simultaneously with the technical sessions were held the commercial and the accounting sessions. These comprised reports of the various committees in addition to the following papers: "Costs and Statistics," by T. J. Walsh; "Appraisals, by D. C. Jackson; "Variations in Public Service Systems of Accounting, by E. C. Scobell; "Accounting for Merchandise Sales," by H. B. Lohmeyer; "Suspense Accounts," by Frederick Schmitt; "Mechanical Sorting and Tabulating Systems," by F. A. Birch, G. L. Knight and C. N. Woolsey: "Purchasing, Storing and Accounting of Coal for the New York Edison Co.," by Charles R. Lehmann. Elbert Hubbard also delivered an address on "The Age of Coöperation."

Of particular interest were the concluding remarks of the committee on high load factor and nonpeak business which were in part as follows:

"There are in practically all cities several private generating plants which give as an excuse for operating, the fact that they need steam in large quantities during the winter months for heating their buildings. Although the central-station companies in these cities have made all reasonable efforts to get this business, there are many instances where, at the present time, there is a deadlock in negotiations. These same plants for the most part realize that they could operate more efficiently and economically on central-station service during the summer, but do not see their way clear to signing a long-term contract whereby they must assume certain obligations during the winter months, when they could run more economically on their own private plants.

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*A more complete abstract of this paper will appear in a later issue.

*See "Power," Jan. 6, 1914.

†See "Power," Jan. 27, Feb. 3, 10, 17 and 24, 1914.

"From the standpoint of the central station it could make money on this class of business, if taken only for the summer months as it would be distinctly off-peak.

"It would, therefore, seem a good proposition for both interests, for the central station to offer a short-term contract for summer business from existing plants.

"However, as against this, consideration must be given to the effect such a policy would have upon the other customers of the company. In other words:

"1. Would such a course indicate that the central station admits it cannot operate in large buildings economically if steam is used in any appreciable quantity for heating?

"2. Would not the present large installations, where central-station service has superseded a private plant and shown an economy, start up their own plants during the winter months and use their exhaust steam for heating?

"Consideration must also be given to another point, whether by demonstrating the superiority of central-station service during the summer months, we could obtain some of this business for the entire year which we otherwise could not get."

On Friday the third general session was held and the following officers elected for the ensuing year: President, H. H. Scott, New York; first vice-president, E. W. Lloyd, Chicago; second vice-president, H. A. Wagner, Baltimore; third vice-president, L. D. Gibbs, Boston; fourth vice-president, J. S. Bleecker, Columbus, Ga.; treasurer, W. F. Wells, Brooklyn and the executive committee to serve three years, Paul Spencer, Philadelphia; A. C. Einstein, St. Louis, and Walter Newmiller, New York.

A splendid exhibit of electrical apparatus and accessories was held in the roof garden of the Bellevue-Stratford.

ENGINEERING AFFAIRS

The National Gas Engine Association will hold its annual meeting at the La Salle Hotel, Chicago, Ill., on June 24, 25 and 26. Among the subjects to be discussed will be a standard belt speed, horsepower rating and a standard brake. The local entertainment committee has provided some wholesome entertainment, including a boat trip to Michigan City, where supper will be served, and a moonlight trip back to Chicago. Everyone interested in gas engines is invited to attend the convention.

*

The forty-second annual commencement of Stevens Institute of Technology, Hoboken, N. J., was held on June 9, at which 65 members of the graduating class received the degree of mechanical engineer. Henry S. Pritchett, Sc.D., LL.D., addressed the graduating class in well chosen remarks founded on the philosophy of Epictetus: "(1) Don't quarrel with the universe; (2) Touch elbows with the rank and file; (3) Live as much as you can each day in the open air, and (4) Every day speak with someone higher, wiser than yourself." The Stillman prize to the member of the senior class who prepares the best paper on a subject pertaining to technology was awarded to Hermann Henry Albers, of Brooklyn, N. Y. His subject was "Devices and Methods for Measuring High and Low Temperatures, with Special Reference to Engineering Problems."

*

Big Realty Building Again Operates Its Old Plant— The Metropolitan Realty Building, a fifteen story manufacturing structure, occupying a 50 by 200-ft. plot north of the Brooklyn Bridge, in New York City, will repair its old plant and make its own current. In 1892, when the building was erected, a power plant was installed to furnish heat, light and power to the tenants. After the plant had been operated for some years, the management was induced to shut it down because of repairs and other excessive costs, and buy its current. After a three-year trial of Edison service and two years more of the New York Service Co., a subsidiary concern, the management has concluded to let the Engineering Supervision Co. of New York operate the old plant under a guarantee of economy.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"You must be born with wheels in your head if you would make a good engineer," says a contemporary. So that's the reason, is it? Guess we'll ask our old friend Coroner Tim Healy to order an autopsy and verify this statement. Any good engineer got a wheel to lend?

*

The House Appropriations Committee wants the Federal Children's Bureau budget cut from $164,640 to $25,640; free seeds (for constituents) get $165,000, and to stamp out the hog cholera, they'll let go of $400,000. Looks like the "hog" cholera had its incipiency in the House.

*

A high forehead says that insomnia points to the time "when man shall be able to use his cerebral engine every hour of his brief life." It would be a brief life for most of us if our brain engines attempted one of those fool 24-hour work tests. We hit the hay around eleven o'clock, and then it's good night till the morning after the night before—unless we are at a convention, when we just can't be beguiled by O'Morpheus into retiring before eleven-thirty.

*

Good old Fred Raven struck the keynote when, at the Illinois State convention, he wondered "if all appreciated the fact that the opportunities of the organization were only half realized." When Fred opens his mouth he says something.

*

"Who over here ever heard of Ding, the English aviator?" asks the New York "Sun". Why, old son, Ding is the brother of our friend By Ding, who goes up in the air so much; an uncle of Gol Ding, and second cousin to those expatriated Americans the Ding-Bustits.

*

Last year Berlin consumed nearly twenty billion gallons of water. Since when have the Berliners taken to drinking this stuff? Sounds like a willful waste and a woeful want of "taste."

*

Convention time! It toddles around regularly each year, along with the humidity, the 'skeeters and the prickly heat; sulphur and molasses can't get it out of your system once the convention rash breaks out. Its only remedy is Go-to-It!

This year the Illinois boys started the ball to rolling with a corking good convention. Then New Jersey rounded the corner, eleven associations strong, and the Master Boiler Makers woke up old Philadelphia after the manner of boiler makers; Iowa, and Kansas, and Kentucky, the big national meet of the American Order at Baltimore—

Say, son, it's in the air; just one dum thing after the other right up to the big fest at Milwaukee!

The engineer who never attended a convention—shucks, Zeke, there ain't no such thing! Every engineer goes; if not in person, he's there in spirit. And he knows his interests are being taken care of and his delegates are reflecting credit on his craft!

INSTALLING AN ISOLATED PLANT

Boston Pumping-Station Explosion

An explosion of sewer gas completely wrecked the small screenhouse at the northwest end of the Metropolitan sewage pumping station near Chelsea bridge, East Boston, about noon on June 1, smashing windows, strewing the wreckage for 50 ft. around and causing the death of three attendants and the serious injury of several others.

The house, which was about 25 ft. square, was strongly built of brick and steel, as is evidenced by the fact that several large sections of the walls were blown some distance without breaking. The station cares for about 200,000,000 gal. of sewage per day, about one third of the total amount for the city of Boston. Pending repairs, the sewage will be discharged through auxiliary gates without screening.

※

St. Paul Electric Power Rates

The assembly and the board of aldermen, in surrendering control of the affairs of the city of St. Paul to their successors under the new commission form of government, have just recommended further investigation with a view to the adoption of an ordinance reducing the electric rates now charged by the Gaslight Co.

Supporting this movement, the Builders' Exchange of the city lately sent a communication to the mayor expressing particular interest in the power rates, and asserting that manufacturers in Minneapolis enjoy more favorable rates and conditions for electric-power service. The difference is said by the Exchange to be sufficient to give Minneapolis an advantage in the location of new manufactures in the Twin Cities.

PERSONALS

A. A. Potter, for several years professor of steam and gas engineering at the Kansas State Agricultural College, has been made dean of the engineering division and director of the engineering experimenting station of the same institution. Mr. Potter will still retain the professorship in steam and gas engineering.

Harold Almert, Chicago, Ill., has been retained as technical counsel by the Washington Railway Electric Co. and the Potomac Electric Power Co., of Washington, D. C. The appraisal division of Mr. Almert's staff will make a detailed inventory and valuation of the property of these companies, not only in Washington, but throughout the District of Columbia, in preparation for a hearing before the Federal Utility Commission, which commission appeared before the local committee of Congress, through the corporation counsel, on June 2, and declared itself in favor of immediate Federal ownership of the utilities in the District of Columbia.

Richard Ward Baker has been in the employ of the Watson-Stillman Co., Aldine, N. J., and New York City, for fifty years. The company has rewarded him by the presentation of a substantial check and extending to him a month's vacation. Mr. Baker began his apprenticeship in a small factory in Grand St., New York City, on June 2, 1864, and has been continuously identified with the Watson-Stillman Co. and its predecessor ever since. A special resolution was passed by the board of directors of the company expressing its high esteem of Mr. Baker's long and loyal service, and the resolution was presented to him in the presence of the employees, officers and directors of the company at its Aldine plant.

Gano Dunn, president of the J. G. White Engineering Corporation, in recognition of accomplishments and distinction in science and electrical engineering, had the honorary degree of master of science conferred on him on May 29, at the celebration of the fiftieth anniversary of the founding of the School of Mines of Columbia University. Mr. Dunn is president of the United Engineering Society and has been president of the American Institute of Electrical Engineers and the New York Electrical Society. He is a member of the British Institution of Electrical Engineers, the International Electrotechnical Commission, the American Society of Mechanical Engineers and other scientific and engineering bodies and was United States delegate to and vice-president of the last International Electrotechnical Congress which was held in Turin, Italy, in 1912.

Electric Drive to Speed Up Machine Shop—Speeding up a machine shop by means of an electric drive has been proved possible at a shop maintained by the city of Chicago for repair work on pumping and other apparatus for the water department. Formerly the shop was driven by a slide-valve steam engine through intricate line shafting. No-load tests made showed that 53 per cent. of the power generated was required to drive the line shafting and idle pulleys. During the year 1913 a motor-generator set was substituted for the steam engine, with the result that the line-shaft losses have been reduced from 53 to 10.5 per cent. Furthermore it has been possible to increase the speed of the line shafting a third, and the men in the shops have unconsciously speeded up correspondingly.—"Engineering Record:"

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans have been prepared for the construction of a substation for the Buffalo General Electric Co., Buffalo, N. Y. The estimated cost is $20,000.

The Orange County Lighting Co., Middletown, N. Y., has had plans prepared for the construction of a new gas plant.

The citizens of Butler, N. J., contemplate installing a municipal electric-light plant costing $30,000.

A 1500-kw. turbo-generator and new boiler equipment will be installed at the plant of the Morris & Somerset Electric Co., Morristown, N. J. J. H. Drake is manager.

The Public Service Electric Co., Trenton, N. J., contemplates constructing a substation on Adeline St.

Bids will be received until noon, July 8, by the Waston Electric Light Commission, Easton, Md., for a complete power and lighting equipment. The Reliance Engineering Co., 312 Fourth National Bank Bldg., Cincinnati, Ohio, is the engineer.

Bids will be received by the supervising architect, Treasury Department, Washington, D. C., until July 8, for repairing the mechanical equipment at the United States Treasury, Winder and Butler buildings, Washington.

SOUTHERN STATES

Fire destroyed the power house of the Sampson Power Co., Clinton, N. C. Loss, $5000.

According to press reports the Savannah Lighting Co., Savannah, Ga., will remodel its power plant and substations. New equipment will be installed. The estimated cost is $200,000. The Schofield Engineering Co., Philadelphia, Penn., is the engineer-in-charge.

The installation of an electric-light plant in Camden, Tenn., is being considered by J. S. Madey & Son.

Gotthart Kapfhammer, 1506 Shelby St., Louisville, Ky., is in the market for a motor to operate special baking equipment.

CENTRAL STATES

Bids will be received by the commissioner of purchases and supplies, City Hall, Cleveland, Ohio, until noon, June 19, for furnishing and installing two 300-hp. water tube boilers for the Infirmary, Warrensville, Ohio.

Bids will be received by the commissioner of purchases and supplies, City Hall, Cleveland, Ohio, until noon, June 19, for the construction of stokers for the two 300-hp. boilers for the Infirmary, Warrensville, Ohio.

Bids will be received by the commissioner of purchases and supplies, Room 513, City Hall, Cleveland, Ohio, until noon, June 19, for the construction of stokers for two 250-hp. boilers for the City Hospital.

The Logan Light & Power Co., Logan, Ohio, which was recently bought by Arthur D. Foster and Francis R. Weller, will be enlarged. A new power house will be built and also a generating station.

According to press reports the East Jordan Light & Power Co., East Jordan, Mich., will install a tandem compound Ideal engine, a condenser, one 100-kw. Bullock generator.

According to press reports the board of managers of the Hurley Hospital, Flint, Mich., contemplates purchasing a new power plant for the hospital costing $9000.

The C. Reiss Coal Co., Waukegan, Ill., will establish a generating plant to supply power for its coal dock.

WEST OF THE MISSISSIPPI

Nash & Co., South Bend, Ind., are preparing plans for the construction of a municipal electric-light plant and pumping station at Earlville, Iowa.

The Oscar Claussen Engineering Co., 314 Commercial Bldg., St. Paul, Minn., is preparing plans for the construction of a municipal electric-light system at Parker, S. D. The estimated cost is $27,000.

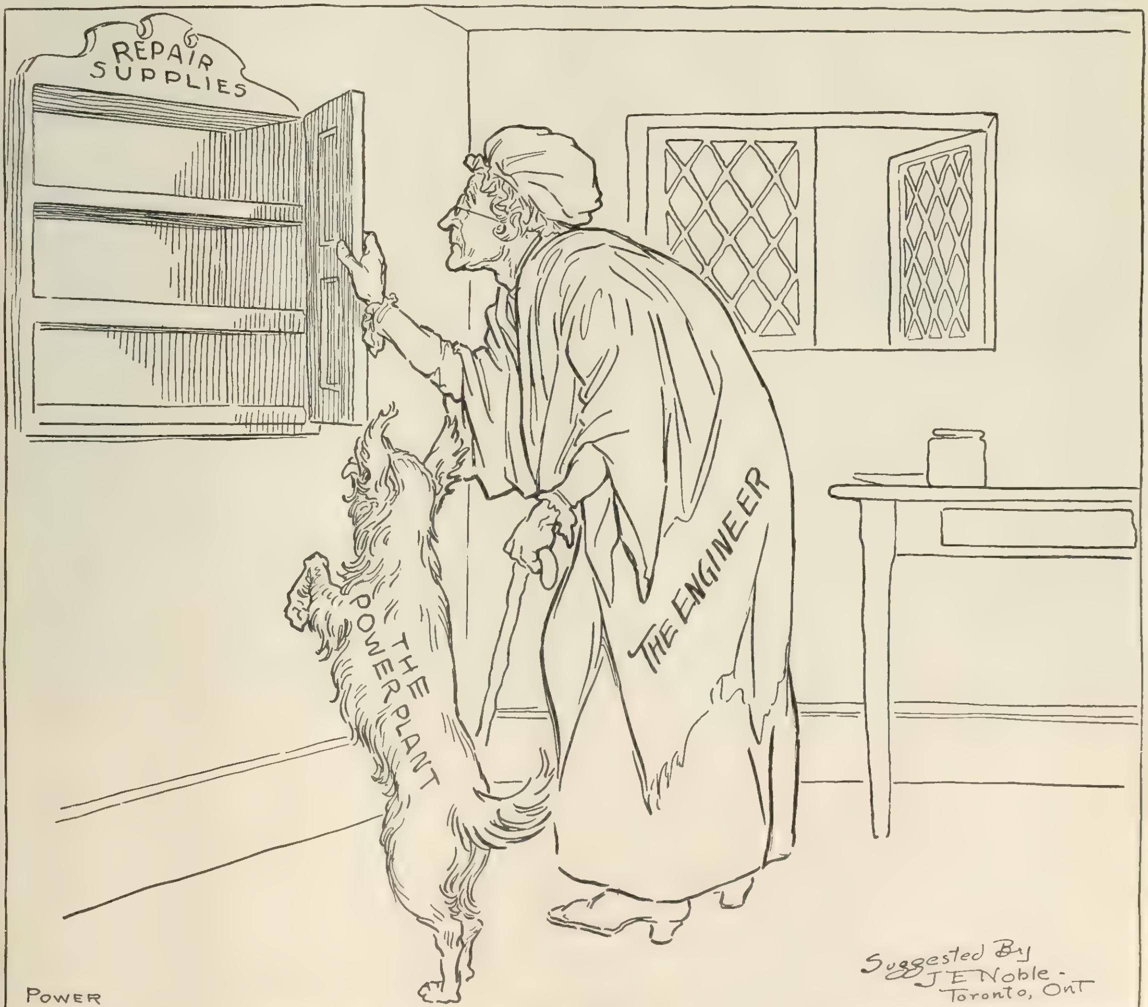
Bids will be received by W. F. Baker, city clerk, Coldwater, Kan., until 1 p.m., June 25, for improving the electric-light plant and water-works. One 75-kw. generator, one 25-hp. motor and equipment and a 100-hp. oil engine will be required.

At a recent election the citizens voted to install a municipal electric-light plant at Vermillion, Kan., costing $10,000.

At a recent election in Los Angeles, Calif., bonds for $6,500,000 to complete the aqueduct power project and for a distributing system were voted.

POWER

Vol. 39. NEW YORK, JUNE 23, 1914 No. 25



"AND SO THE POOR DOG GOT NONE"

First Buckeye-Mobile in Commercial Service in America

SYNOPSIS—The first Buckeye-mobile sold and installed in America is of 115 hp. capacity. It occupies in actual floor area a space 17 ft. 10 in. long and 7 ft. 6 in. wide. The coal consumption per indicated horsepower on test was 1.33 lb. It is directly coupled to a 75-kw. alternator.

⁂

The first Buckeye-mobile sold and installed in America (there is an experimental one used at the works of the makers, the Buckeye Engine Co., Salem, Ohio) is in operation at the works of the International Cork Co., Sutton St., Greenpoint, L. I., N. Y.

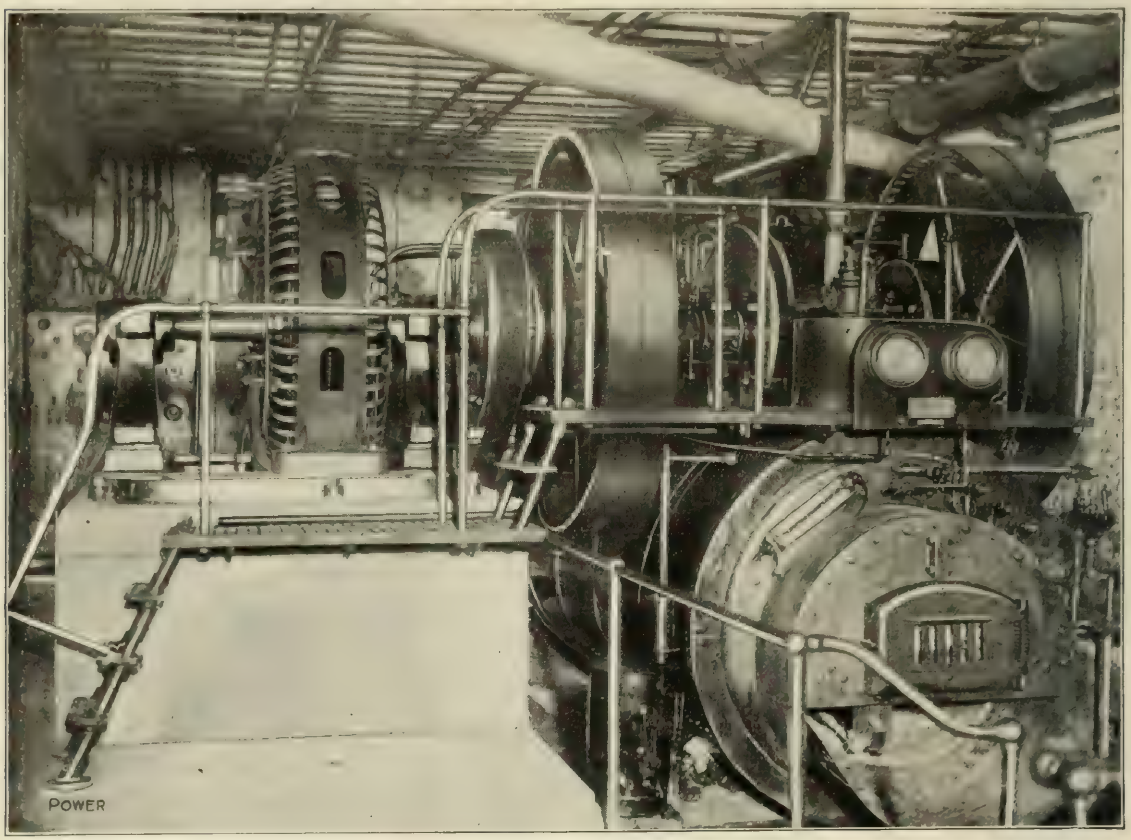


FIG. 1. FRONT VIEW OF THE 115-HP. BUCKEYE-MOBILE AT THE INTERNATIONAL CORK CO., GREENPOINT, LONG ISLAND, N. Y.

This particular unit, Fig. 1, is of 115 hp. capacity and stands 9 ft. high from the base to the top of the engine flywheel. As the basement where it is placed is low, it was necessary to put the outfit in a pit 2 ft. deep, giving an 18-in. clearance between the top of this flywheel and the ceiling rafters.

The unit sets on a concrete foundation and is anchored by only two 1¼-in. bolts at the left front foot; the opposite foot rests on two 1½-in. rollers, supported by a channel plate. The two center feet each rest on four rolls of the same size and both rear feet are on two 1½-in. rolls. This arrangement gives free expansive movement. The furnace contains 38 sq.ft. and the 91 tubes 262 sq.ft. of heating surface, a total of 300.

Fig. 2 is a rear view of the unit. The generator is on a concrete foundation and the base is level with the operating platform of the engine. A 7-kw., 125-volt exciter unit is belt driven from the engine shaft at 1210 r.p.m.

The engine shaft is coupled to a 75-kw. Westinghouse, alternating-current generator, which produces 220-volt, three-phase, 60-cycle current at 257 r.p.m. The coupling is flexible, to allow for change in alignment, due to any slight movement of the Buckeye-mobile.

The principal weights of the unit parts are as follows: The boiler, with feet and saddle, weighs 12,000 lb., or six tons; the bedplate, 2400 lb.; the engine cylinder, 1400 lb.; the crankshaft, 1500 lb.; and the two flywheels, 3000 lb.

In Fig. 3 are shown the dimensions of the 115-hp. Buckeye-mobile, the total length of which is 17 ft. 10 in.; a space of about 10 ft. 6 in. is required for removing tubes, at the head end, and 4 ft. for removing the super-

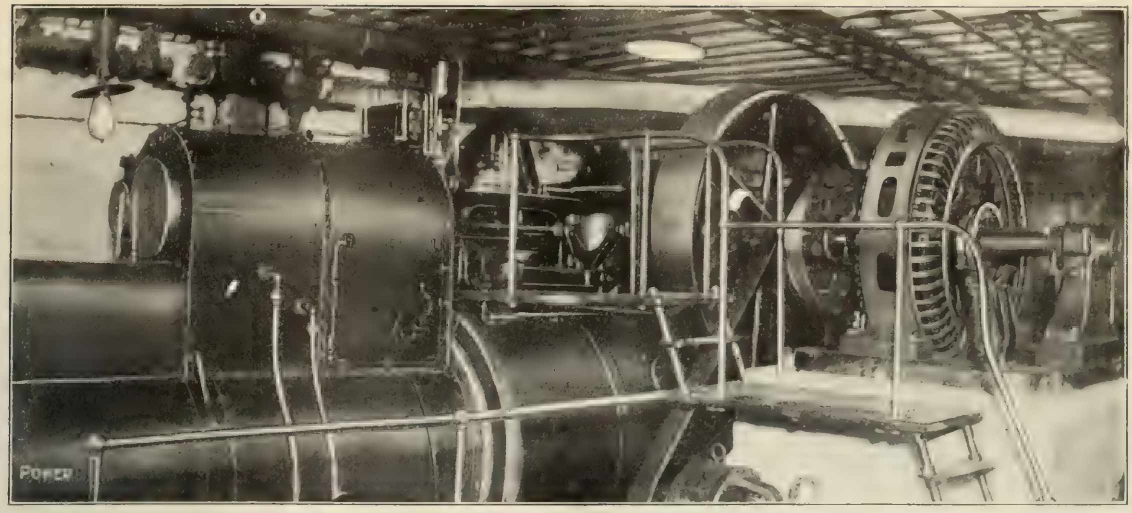


Fig. 2. View of the Buckeye-Mobile from the Side

heater from the rear end, making a total required length of 32 ft. 6 in. The 10-ft. space in front of the boiler, however, is necessary for a firing place in any event. The width of the engine is 7 ft. 6 in. and the generator adds, with its foundation, 6 ft., or a total of 13 ft. 6 in. The total ground area required by the unit is 13 ft. 6 in. by 32 ft. 4 in. for 115 hp. in output.

The following figures were obtained at the shop test of the unit on Apr. 1:

NO. 4 BUCKEYE-MOBILE, 115 HP., NONCONDENSING

Pocahontas coal	14,500 B.t.u.
Duration of test, 11 a.m. to 7 p.m.	8 hours
Speed	248 r.p.m.
Indicated horsepower	118
Total steam per hour	1,574.5 lb.
Steam per i.hp	13.3 lb.
Total coal per hour	156.4 lb.
Coal per i.hp	1.33 lb.
Boiler pressure	210 lb.
Superheat, high-pressure cylinder	171 deg.
Superheat, low-pressure cylinder	56 deg.
Temperature feed water	192 deg.
Temperature stack gases	398 deg.

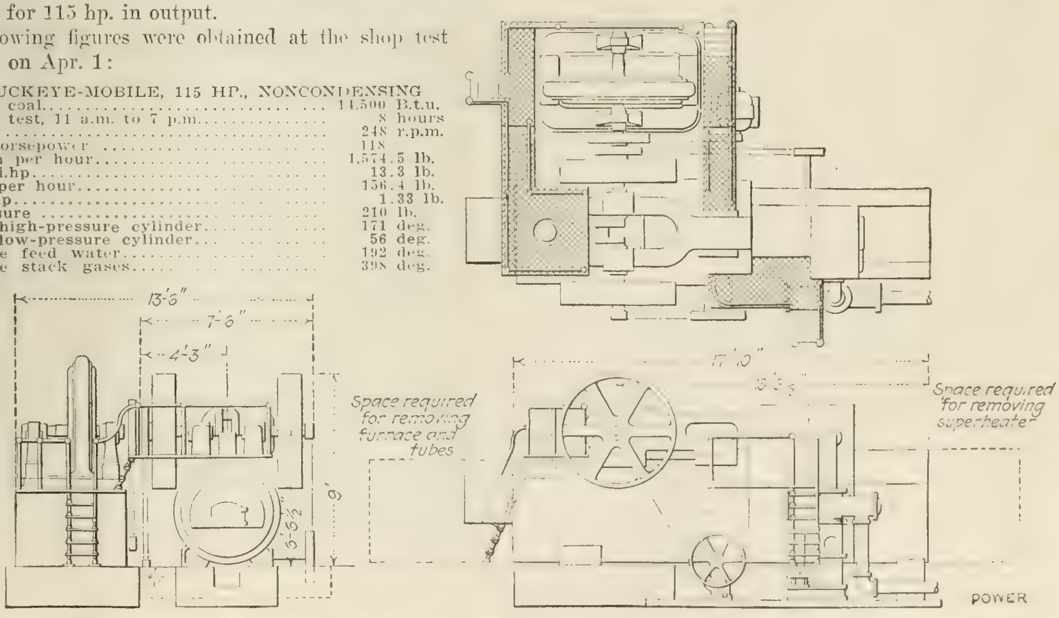

13'6"
7'6"
4'3"
9'
3'6½"
Space required for removing furnace and tubes
17'0"
13'3½"
Space required for removing superheater
POWER

Fig. 3. Elevations and Plan, Showing Space Occupied by a 115-Hp. Buckeye-Mobile

The diagrams, Fig. 4, are from the high- and low-pressure cylinders taken during the shop test.

This first installation is a good example of the adaptability of the Buckeye-mobile in restricted places where it would be impracticable to install the ordinary type of boiler and engine.

Due to the demand for more power (an additional building is being erected) it was necessary for the company to solve the problem of additional power units. The original power plant is in the basement of the brick building. The boilers occupy the width of the boiler room and the engine is on the opposite side of the basement, and separated from the boilers by a brick wall. The basement is about 10 ft. high, and any additions in the ordinary steam boiler and engine equipment would require considerable alterations to the building.

It was finally decided to install a Buckeye-mobile of 115 hp. capacity. This would eliminate changing the boiler room, save floor space, provide a "two-in-one unit," and, furthermore, produce a horsepower-hour more economically than any other type of steam prime mover.

The time required to place the unit after delivery was 13 days, two days longer than with favorable conditions for handling the parts.

From the figures given in the test it will be seen that the unit will deliver a horsepower-hour on less than 1½ lb. of coal, running noncondensing. In fact, the builders guarantee to forfeit $1000 for every 1/10 lb. of coal required per indicated horsepower above the guarantee, with a nominal bonus for saving in fuel below the guaranteed amount, the calorific value of the coal being the basis of the guarantee.

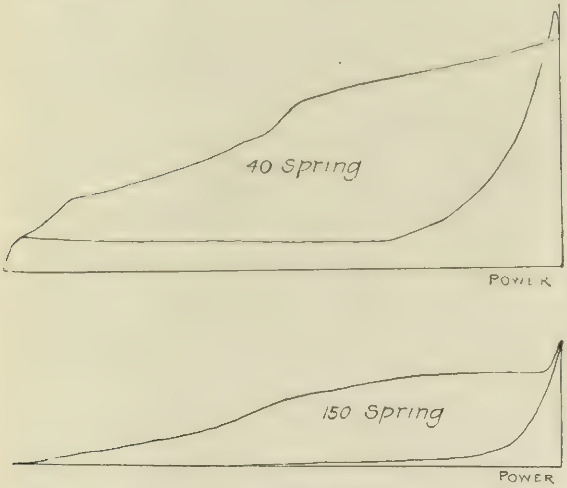


Fig. 4. Diagrams Taken during Shop Test

Aside from the compactness of the power plant the big thing is that this small size of Buckeye-mobile produces power on less fuel than the largest central-station unit, and the consumer of power in small quantities can produce it as cheaply as if the ordinary boiler and engine unit, many times this capacity, were used.

⁂

Use of Rheostats to Control Alternator Voltage

There are usually two rheostats on each alternator panel, one in the exciter field circuit and the other in the alternator field circuit; by the use of which the alternator voltage may be adjusted. The question often arises as to which of these should be used.

Exciters are nearly always rated at 125 volts, but this does not mean that they are to be run at this voltage; usually it is less than this. The alternator fields consume the full output of the exciter, whereas only about 2 per cent. of the exciter capacity is used in exciting its own fields. Therefore, a resistance inserted in series with the alternator field will consume many times the power lost when a proportionate resistance is inserted in series with the exciter field. Hence it is more economical to operate with the alternator rheostat cut out and with proper exciter voltage to maintain the required alternator voltage. The only exception to this rule is in case the resultant exciter voltage is so low that the exciter is operating far below the knee of its magnetic saturation curve so that an unstable voltage results.

When two alternators are to be operated together their exciters are first paralleled, the incoming exciter voltage being first made the same as that of the unit in operation. In order to adjust the voltage of the incoming alternator to correspond with the alternating busbar voltage, it is then necessary to use the rheostat of the incoming alternator. When the machines are synchronized, the alternator rheostats are adjusted to reduce the cross-current to a minimum. However, the general rule still holds that as little resistance as possible should be inserted in the alternator field circuits.

When a Tirrill regulator is used the exciter rheostats are set at predetermined points corresponding to very weak fields. The alternator rheostats are usually cut out altogether, or nearly so. The regulator then short-circuits the exciter field rheostats controlling the exciter voltage so as to maintain steady alternating busbar voltage.

⁂

Tightening Commutators in Use

Quite frequently, the commutator segments of large direct-current machines develop high or low bars and show signs of loosening; also, new segments are inserted and it becomes desirable to tighten up the commutator. This requires baking the commutator to be most effective. The shellac binder should be softened and the commutator tightened while hot, then as it cools, the shellac which has run into all the interstices, sets and binds the whole into a solid unit.

It would be a rather difficult task to remove a large commutator to bake it, and it is, of course, impossible to bake armature and all. An equivalent effect can be obtained quite simply. The machine may be operated as a generator with the armature short-circuited and a weak field to obtain full-load current or with a low-resistance artificial load. The brushes should be materially shifted from the neutral point. As a result of this shifting they are brought into a zone where there is considerable difference in voltage between adjacent bars. The brushes covering these bars cause rather heavy local currents to flow through the commutator segments and brushes, heating them without unduly heating the armature itself.

There will be some sparking, but this is usually immaterial as the commutator will later be turned down. When the commutator is thoroughly heated, care being taken not to overheat and melt the solder in the risers, the tightening screws are brought up and the commutator allowed to cool. When cool it may be turned down and smoothed, the brushes returned to their correct operating position, and any accumulated copper removed from under them. The machine is then ready for operation again.

⁂

The New 25,000-kw. Parsons Turbine, at the Commonwealth Station in Chicago, is said to have done a kilowatt hour on 18,300 B.t.u., and made a sustained run on 1.92 lb. of coal containing 10,300 B.t.u. per pound, with a 58 per cent. load factor.

⁂

An Electric Diesel-engine Railroad Motor Car was tested in southern Sweden last January. It weighs 33 tons and was run at a speed of 34 miles per hour on level track, and at about 20 miles an hour on a grade of 1 in 100. Altogether 2200 miles were covered. The consumption of crude oil averaged 9.3 lb. per mile, according to the Zeitung des Vereines Deutscher Eisenbahn Verwaltungen.

Pontchartrain Hotel Plant Records

By E. Y. Dow

The Pontchartrain, one of Detroit's well known hotels, is a 15-story structure containing 450 rooms. As usual, the building requires varied services, including lighting, general power, elevators, refrigeration, vacuum cleaning, hot water for house and laundry, heating, etc. The plant contains eight electric and two hydraulic elevators, 11 fans, 12 centrifugal motor-driven pumps and various machines with motors ranging from ½ to 40 hp. There is also an air washer with its fans and pumps and a small machine-repair shop, which requires more or less power.

Steam is furnished at 100 lb. for the direct-acting pumps and at 2 lb. pressure for the heating by the Murphy Power Co., and also current for lighting and power. Considerable ice is used in the hotel and some refrigeration is required. Two 25-ton, motor-driven Wisconsin carbonic compressors having a capacity to make 24 tons of ice in 24 hr. were installed to handle this load, and as satisfactory rates were not offered by the central station, a gas-engine-driven generating unit was purchased primarily to care for the refrigerating load and reduce the maximum demand on the central station. The engine was a three-cylinder Nash, rated at 185 hp. and directly connected to a Western Electric three-wire, 125-250-volt generator.

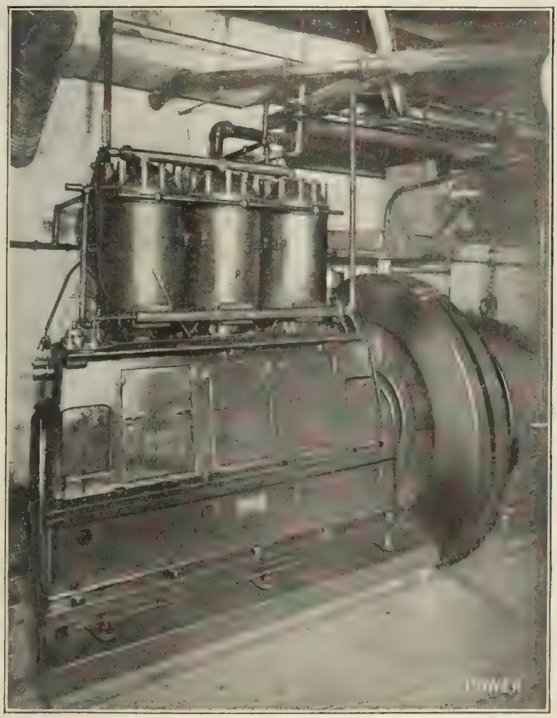


Fig. 1. The 185-Hp. Gas-Engine Unit

In addition to the refrigerating load, which for the last two months has been 20 tons above the average, due to carrying the refrigeration in three outside buildings, the generating unit has operated the elevators, fans and electric-driven pumps, leaving the lighting for the central station. In the early morning hours it has frequently carried the entire load. By utilizing the jacket water and passing the exhaust gases through a heater, the unit has also supplied sufficient hot water for the kitchen and laundry. The engine uses city gas at a cost of 45c. per 1000 cu.ft. and a complete record of the plant for the month of February shows that with its varying power load it is supplying cheaper current than the central station. Following is a tabulation of the results:

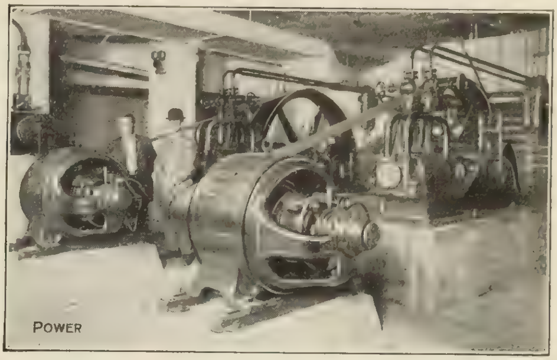


Fig. 2. The Refrigerating Plant

Total gas consumption, cu.ft.	1,565,700
Total current generated, kilowatt-hours	52,100
Cost of gas at 45c. per 1000 cu.ft.	$704.57
Oil and waste	24.91
Interest and depreciation, 15% on engine, generator and switchboard	85.00
Labor	28.00
Total cost	$842.48
Former cost of hot water	250.00
Net cost of current	$592.48
Cost per kilowatt-hour, cents	1.137
Current purchased, kilowatt-hours	42,235
Total cost	$744.19
Cost per kilowatt-hour, cents	1.762

It is apparent that there is a difference in the cost of current of over 0.6c. per kw.-hr. and even without the reduction caused by the hot water, the difference is 0.15c. in favor of the gas engine. With the expensive fuel used this is an "eye-opener." It may well be imagined that a steam plant would do much better, as it would furnish the live steam for the pumps and the exhaust steam would be available for heating.

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Utah Breaks Coal Record—The production of coal in Utah in 1913 was 3,254,828 short tons, with a value at the mines of $5,384,127, according to E. W. Parker, of the United States Geological Survey. In 1912, for the first time, Utah's coal production exceded 3,000,000 tons, the output in that year amounting to 3,016,149 short tons, valued at $5,046,451, a gain of more than half a million tons over 1911; nearly a quarter of a million tons more was mined in 1913. In 1912 the industry suffered from a scarcity of labor due to the exodus of foreign miners to the scene of war in the Balkan States, but the returns for 1913 indicate a plentiful supply of labor, as an increase of more than 800 men were employed in the coal mines compared with the preceding year.

Nearly 90 per cent. of the total coal production of Utah is mined in Carbon County, which contains a large part of the great Uinta Basin. This county produced in 1913, 2,880,102 short tons, out of a total for the state of 3,254,828 tons.

Comparing Boiler Laws

By Danny Hogan

The article in Power of May 19, by J. W. F. Macdonald, on Canadian boiler rules, is worthy of further discussion, in view of the steps now being taken to formulate a model boiler law in the United States. It is, or should be, the aim of such law makers to establish standards easily understood by builder, buyer and inspector, to avoid ambiguity and to fix values as regards tensile and shearing strengths, and factors of safety, so that he who runs may read aright. Even though it was not realized in the making, doubtless this view was in mind in forming the Canadian laws, but they fall far short of the Massachusetts rules in several respects.

For example, Massachusetts sets certain factors of safety to be used on boilers installed before the law was passed, fixes tensile-strength values on such boilers where stamps cannot be found, gives estimates on rivet diameters per thickness of plate, and varies the factor of safety on lap-seam boilers, on account of age. These important details are not contained in the laws of our neighbors, and, by so much, owners and inspectors are at a loss to know what to do; they are no better off than before.

As to new boilers, on the tensile-strength question they sit in our pew, but do not prohibit the use of flange steel. It follows that, with a high tensile strength, a boiler will be allowed more pressure, while experience shows that the best steel for shells (or elsewhere) contains less carbon and sulphur content, and is therefore more ductile or less brittle.

Why is it that high tensile strength is considered desirable for any boiler purpose, and especially for shells, in which the plate is cold stretched to points beyond the elastic limits? Certainly for such treatment the mildest, the most ductile steel is desirable, and Massachusetts requires this, while Canada grants more pressure on steel of higher tensile strength and resultantly less positive value.

A low-tensile-strength plate, although it is better, is penalized by less allowance as against the high-tensile-strength plate. There is great need of disposing of this question of tensile strength in order that all builders may be on an equality. The plate makers aim to produce the best plate possible, but in the art the range of tensile strength varies from 6000 to 8000 lb., and this cannot be avoided. If, therefore, a mean tensile strength, say, 56,000, is assumed and stamped, in the event of later tests showing less tensile strength, the plate maker is in trouble. Hence, if he must stamp 56,000, it follows that he will see that the carbon content is high enough to insure the tensile strength, which means more brittle steel. Therefore, in order to give the plate maker liberty to make the "best-ever" steel, we should take a low fixed tensile strength, not more than 52,000 lb., for plates 1 in. or less, and for plates above 1 in., for obvious reasons, 50,000.

Reverting to the Canadian rules, to rivet shear values, it appears that, assuming for lap seams the rivet shear to be 0.7 that of the plate tensile strength, it is not as correct a practice as that in the United States, because the Canadian rules have a wide range in tensile strength —from 52,000 to 65,000 lb. This gives a shear value range of from 36,400 to 45,500 lb for steel rivets. Thus the same lot of rivets would be given varying values due to the plate tensile strength. As a matter of fact, the United States standard, 42,000 lb., is a result of numerous tests by competent authorities and is accepted here as about the average value when made from extra-soft steel to comply with the Massachusetts requirements.

Our Canadian friends, apparently, have not profited by the numerous explosions in this country, due to failure of lap seams, for they have not prohibited lap-seam contraction; they merely require them to be triple riveted, and add 0.5 to the factor of safety on such boilers. The tendency in the United States is to rapidly abolish the lap-seam boilers, and not to permit new ones to be built. In this respect, comparisons are odious, or odorous, as you like.

Concerning the base factor of safety, 4.5 (where we use 5), and additions as penalties, I am of the opinion that the Massachusetts methods are better. The builder secures a contract guaranteeing a certain pressure. In Massachusetts, he knows exactly what to do to have the boiler accepted as standard. But in Canada, by using slightly heavier plate of high tensile strength and allowing for a few additions to the factor of safety, he can get the boiler passed for the required pressure, while as a matter of fact it would not be accepted in Massachusetts, Ohio and other localities in this country. Beyond doubt, in this respect the Massachusetts standards are the best.

On convex and concave heads, however, the Canadian rules are far and away ahead of those in force in this country, including the United States Government rules. I do not know what tests were made or who founded their convex-head rules, but on this detail I acknowledge that they have the advantage and congratulate them. The details on workmanship (Ontario rules, pages 63 to 67) are, with one exception, excellent, and, no doubt, written by one thoroughly familiar with the best shop practice. The exception is in the matter of punching rivet and stay-bolt holes below size. The rules permit punching for rivet holes over $\frac{13}{16}$ in. diameter, $\frac{3}{16}$ in. less than full size, but they contain no limitation as to the thickness of the plate that may be so punched other than diameters greater than plate thickness. Here, we punch $\frac{1}{4}$ in. below size for plates $\frac{3}{8}$ in. and above, which results in the removal of about all the injured section of the plate. Furthermore, the heavier the plate, the greater the injury by punching; hence a limitation should be placed as to the thickness of plate that may be punched, and about $\frac{5}{8}$ in. should be the dividing line. American practice is about at this point.

The limitation of sheets and shells to 10 ft. in length, when made in full ring courses, is questionable for drums on water-tube boilers, but it is good practice for disposing of that atrocity, the single sheet on the bottom horizontal tubular boiler. In the United States no one has questioned the butt joint double strapped, with one row of rivets in double shear, having the outer row in single shear and double pitch. The joint has been in use for years here, and is accepted by all at its face value, usually 82 per cent. But in Canada, this form of joint is penalized by raising the base factor of 4.5 to 5.5, whereas a lap-seam triple riveted would have 4.5 + 0.6, or 5.1.

I am of the opinion that this joint is worthy of more consideration, and, par efficiency, the equal of a butt triple-riveted seam. In regard to stay-bolts used in vertical and locomotive boilers, the general practice in the United States is to omit the washers, nuts, etc, but to finish them with a pneumatic tool, thus forming a neat and strong head on each end. Such work is now being done in a first-class manner, especially on large vertical boilers and in water legs of water-tube boilers. In doing this our builders' practice is to calculate the entire load to be supported by the bolt on the basis that pitch × pitch × pressure is the load, and no value is allowed for plate stiffness or load. Again, to be on the safe side, the load on stay-bolts is low, 6500 lb. for 1¼ in. and below, and 7000 lb. above 1¼. For weldless iron stay-bolts Ontario allows 7000 lb., and for steel ones less than 1½ in., 8000 lb. allowed and above 1½ in., 9000 lb.

With regard to the above, it may be said that the stay-bolts in portable boilers, either of vertical or locomotive types, the bending action is very small; it is practically negligible. But in these boilers internal corrosion is to be considered, and, in addition, it is practically impossible to examine such stay-bolted surface internally. Hence the importance of starting with a low stay-bolt value when building such boilers. In this respect, Massachusetts leads. Clearly such practice increases the factor of safety, and safety is, after all, what is sought.

It has been said also that in several respects it is difficult for an inspector to determine by the Canadian rules just how much of the law applies to boilers in use before the laws were passed. Distinctions were not clearly drawn as applicable to old boilers, and rules should be specific on such matters. Inspectors should have clear, definite instructions, for they are often called on to show why the pressure is ordered reduced and they must be able to convince the owner that the law is behind them.

Commenting on boiler laws in general, it is important that someone has the power delegated to him or to them to amend the rules when needed. For example, in Chicago, in 1903, the city inspector ruled a factor of safety of five should go in force, and, further, that no more lap-seam boilers should be installed. Later, he ruled that a second-hand boiler 15 years old or more, if reinstalled after reinspection, would not be allowed more than 10 lb.

In Ohio, a recent ruling raises the factor of safety on old boilers from 4 to 4.5. Compare, then, the value of this feature with the rules of the United States Government service on steamboat boilers, wherein the factor of safety of the shell or cylinder is about 3.5, based on a rule formulated in 1872, and which it now appears impossible to amend, owing to the fact that it would require an act of Congress to change it.

It is to be hoped that the proposed boiler rules of the American Society of Mechanical Engineers will be so clear and so complete that our Canadian cousins, as well as the states now without boiler laws, will see fit to adopt them, and thus secure the uniformity so greatly desired by builders, inspectors and owners.

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Steam-Electric Power Plant at Hauto, Penn.—III

By Warren O. Rogers

SYNOPSIS—The piping in the Hauto plant is on the sectional plan. There are four main steam headers from the eight boilers and four main boiler-feed lines. The high-pressure steam pipes are dripped to a Holly drip system; the low-pressure lines are drained to a sump and the water is used for wetting the ashes.

*

With the exception of the boiler-feed pumps, Fig. 17, all others in the Hauto plant are in the turbine-room basement. The three boiler-feed pumps are in the pump, pipe and heater bay, between the turbine room and the boiler house. Each is driven by a 125-hp., single-stage turbine at 2900 r.p.m. and can work against a head of about 270 lb. These pumps take water from the two open heaters through suction pipes connected to the main 14-in. header, piped to each heater.

Service Pumps

Feed water is supplied to the heaters by either of five compound duplex 8, 12 and 14 by 12-in. service pumps. The first battery of three pumps is in the turbine-room basement, between Nos. 1 and 2 turbines, as in Fig. 18. The discharge of these pumps is connected to a 10-in. cross header above the water end, with stop valves in both header and riser discharge pipes; thus any pump or section of the header can be cut out of service without interfering with the operation of the other pumps. The crossheader is connected with two main 12-in. lines which terminate in a 12-in. header, the connections being on each side of the feed-water heaters. Fig. 19 shows the details of this piping in the turbine-room basement.

Feed-Water Piping

The feed-water header is back of and above the boiler-feed pumps. Each of the two feed-water heaters has a capacity of 6000 lb. of water per minute with a maximum of 10,000 lb., and rest on concrete piers, as shown in Fig. 17. Each heater is connected to the 12-in. header by two 6-in. pipes, one on the outside of each connection of the feed pipes from the service pumps. This permits of four sources of feed water and practically eliminates any interruption of the supply.

The intake water to the service pumps comes to a main 24-in. header through two 24-in. pipe lines leading to the condenser intake tunnel. This header runs along the rear side of the basement, feeds both batteries of service pumps, and terminates above each battery, as in Fig. 18. Two 12-in. pipes extend from it to a 14-in. header about the pumps, from which 12-in. pipes connect to the suction side of each. The ends of the 14-in. header connect with two 14-in. pipe lines which end in the condenser discharge tunnel. This gives three sources of feed-water supply for each battery of pumps.

In addition to the boiler-feed pumps there are two compound injectors for emergency use discharging into two 6-in. headers in the header room, Fig. 20. The boiler-feed pump 4-in. discharge pipes also connect with a 12-in. header, and both headers are tied by two 6-in. pipes. Two 12-in. mains branch out from each header and run to two 12-in. headers on the second floor of the boiler room, Fig. 21.

A venturi meter, placed in each vertical pipe, measures the total volume of water discharged by the feed pumps to the boilers. From the last-mentioned headers, four 8-in. feed lines extend up to and along the top of the boilers. The two outside pipes supply the first four boilers; the two inside pipes running to the four distant units, each feed line reducing in size to 4 in. at the far end. Details of the piping system are shown in the insert plan and in the elevation drawings, Fig. 22.

The 4-in. branch connections to the individual boilers are a decided departure from common practice. Each boiler is supplied with feed water from two main feed lines, the inlet connection being at each end of the two outside steam drums. From the two feed lines serving each set of four boilers a 4-in. branch line runs horizontally across the boiler and drops to a horizontal manifold on the boiler fronts. From this a riser extends to the top of the boiler setting and extends to a point above the center steam drum, ending in a double outlet tee, a branch pipe running to each outside steam drum and connecting at the top. As the other end of the two steam drums are similarly piped, the water tender can regulate the level from either boiler front by the valves in the vertical legs of the piping.

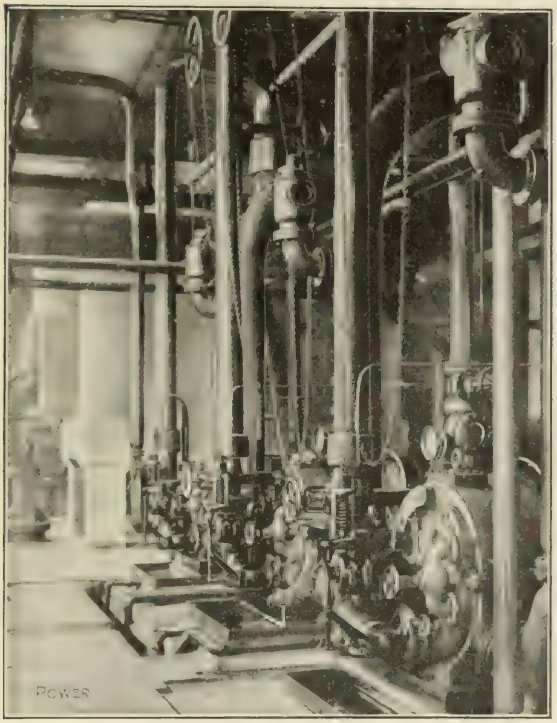


Fig. 17. Turbine-Driven Centrifugal Boiler-Feed Pumps and 6000-10,000-Lb.-per-Min. Capacity Heater

The vertical branch pipe connecting with the feed main and running down the fronts of the boiler setting contains a venturi meter for measuring the water going to the boiler to which it is attached. Both vertical pipes have a check valve, with a gate valve between them and the manifold, convenient for manipulation. These features are shown in Fig. 22. The second set of feed lines is connected to the other boilers in the same manner.

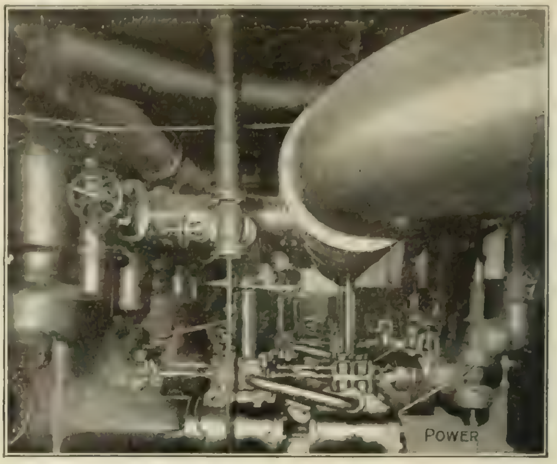


Fig. 18. Service Pumps in the Turbine-Room Basement

Boiler Steam Piping

A 6-in. connection from the center of each outside drum runs to the outside edge of the boiler setting, where each pipe connects to its respective inlet connection of the superheaters. The outlet of each superheater is on the opposite side of the boiler setting and is piped to a 6-in. branch to a 6x7x7-in. vertical manifold. From this manifold two 7-in. pipes connect to their respective 10-in. main steam headers running along the front of the boilers, just below the water-tender gallery, Fig. 23. This applies to the three boilers nearest to the turbine room. The other five boilers are similarly arranged, but the 7-in. pipes from the boiler manifolds join with the 10-in. main steam headers running along the top of the boilers after passing the fourth boiler nearest the turbine room.

These four 10-in. steam lines are brought around to the end of the boiler nearest the turbine room and then drop to the firing-floor level, where they are supported by a concrete pedestal. The four mains then pass through the floor and extend horizontally to the main pipe gallery, each pair of steam lines connecting with 15-in. compensating headers running lengthwise through the pipe gallery. The steam mains from the boilers and the compensating pipes are joined at intervals to 24-in. drums, in which there are long-radius expansion loops between the drums, Fig. 20. From the drums steam leads run to the turbines and pumps.

Each of the three main turbines is supplied by a 15-in. pipe attached to the respective 24-in. drum headers at the top, with a 15-in. stop valve between the drum and

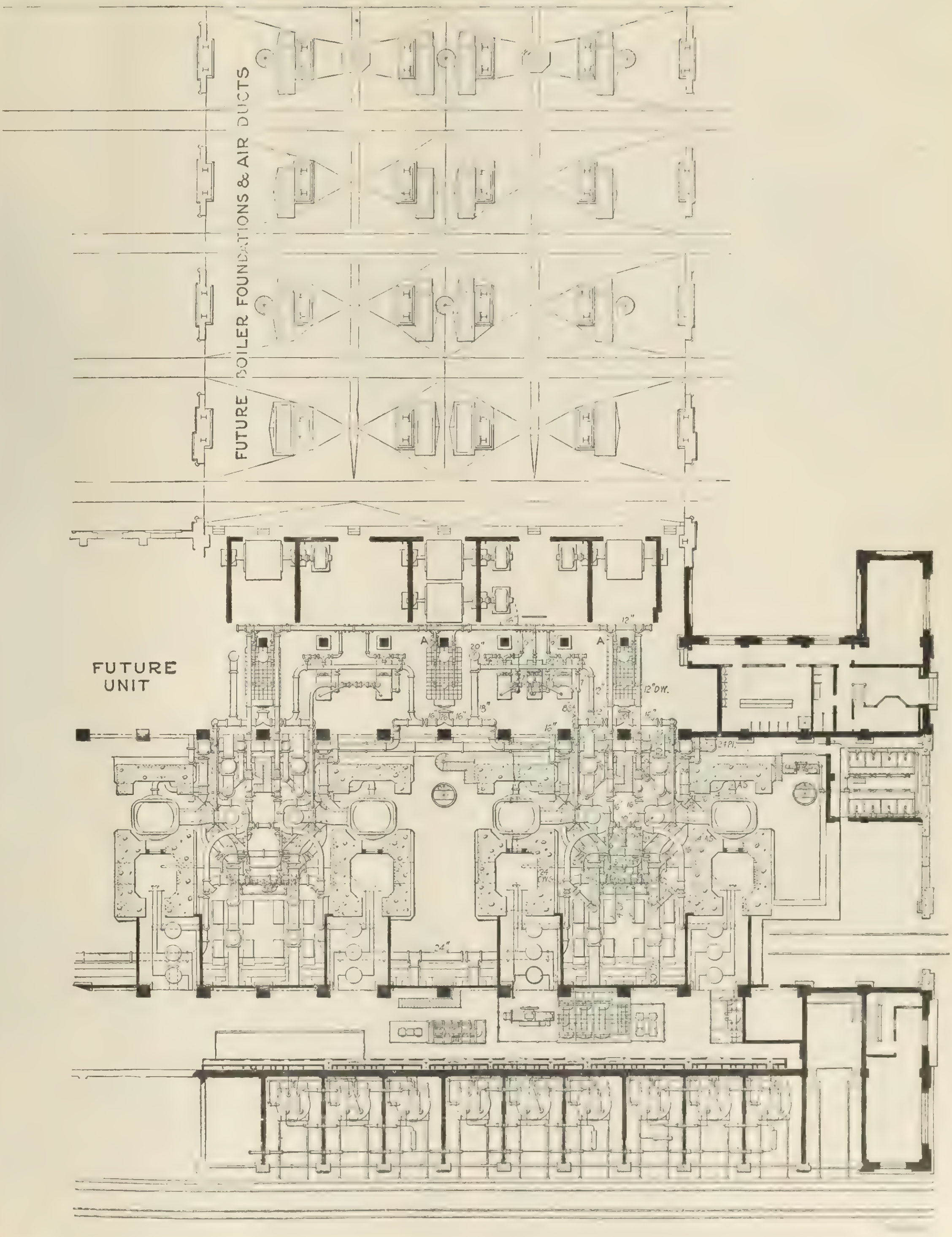


Fig. 19. Details of Piping in the Basement of the Turbine Room. The Outlets of the Air Ducts under the Boilers Are Indicated at the Top of the Cut

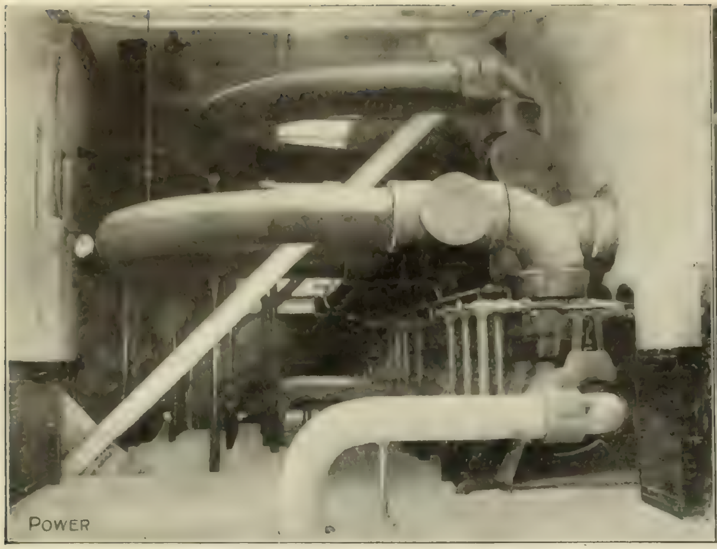


Fig. 20. Header Room, Showing Expansion Loops and Main Headers

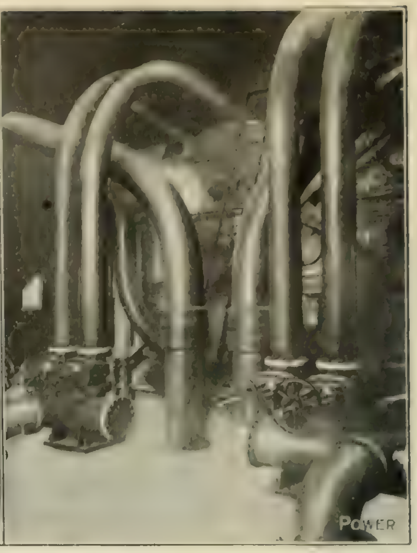


Fig. 21. Feed-Water Headers and Mains, also Steam Lines from the Boilers

the pipe to the turbine. There are also 15-in. valves at the 20-in. drums for the compensating pipes, and all the valve stems conveniently pass through the wall between the pipe gallery and the turbine room and can be manipulated from the turbine-room gallery. This allows shutting off the steam from the compensating headers and from the turbine from outside the pipe gallery in case it is necessary.

Condenser Exhaust-Steam Piping

The condensers of the main turbines are connected in pairs to 36-in. specially designed atmospheric relief valves, each having an air dashpot in conjunction with an independent, oil-operated cylinder working under 25 lb. oil pressure. As shown in Fig. 24, the cylinder is fitted with a dead-weight relief valve on its upper side. Each relief valve also has a float valve, which maintains a constant level in the water seal. To the 40-in. tee connection between each relief valve an expansion joint is attached, from the top of which a 44-in. square exhaust pipe extends up to an elbow and then runs horizontally under the header room; it then turns and connects to a round vertical 48-in. exhaust pipe which passes through the roof.

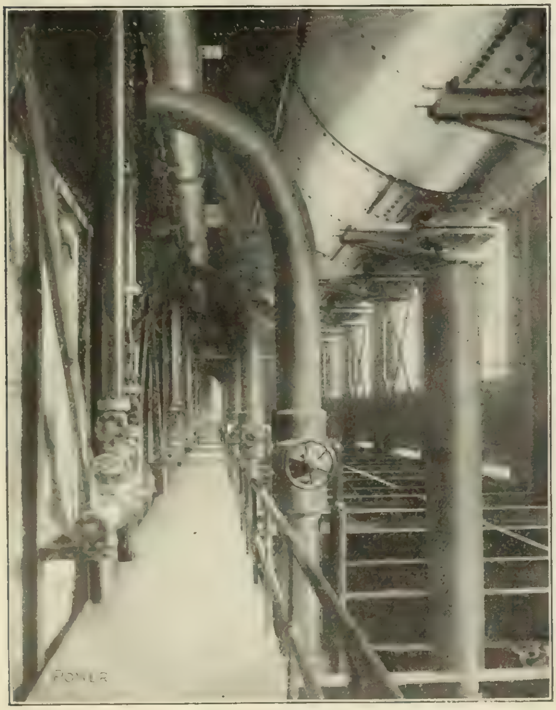


Fig. 23. Water-Tenders' Aisle, Showing Coal Bunkers, High-Pressure Steam Lines and Feed-Water Connections

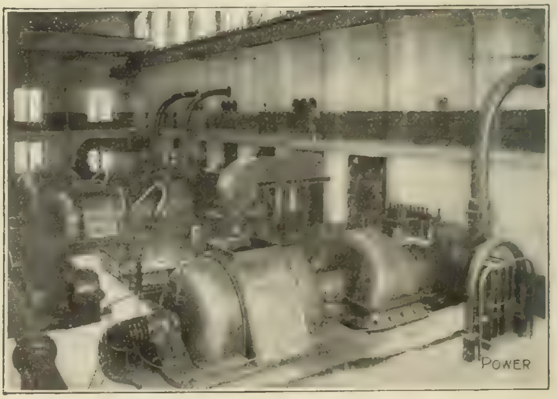


Fig. 24. Showing Atmospheric Relief Valves and Atmospheric Exhaust Pipes from the Main Turbines

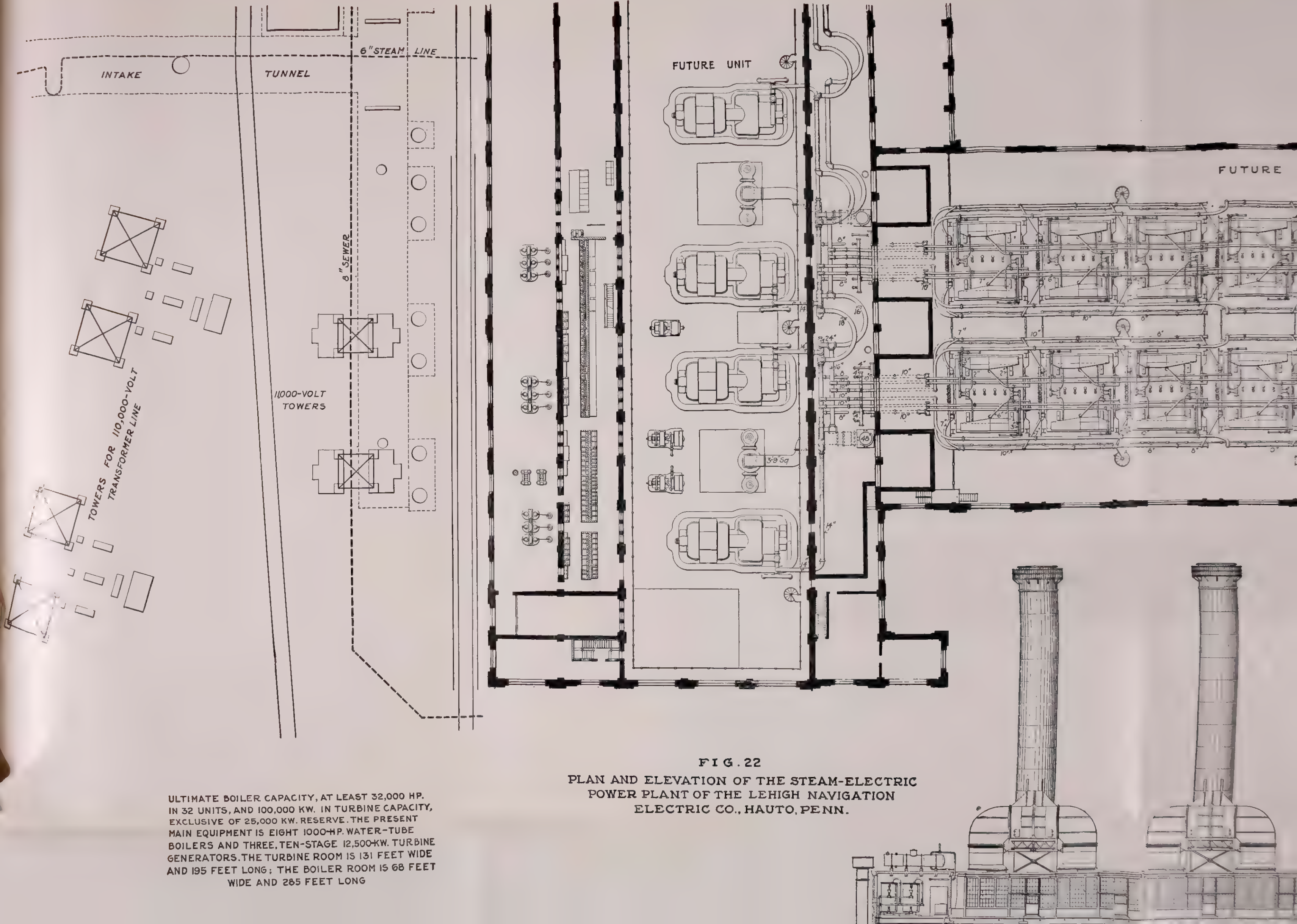
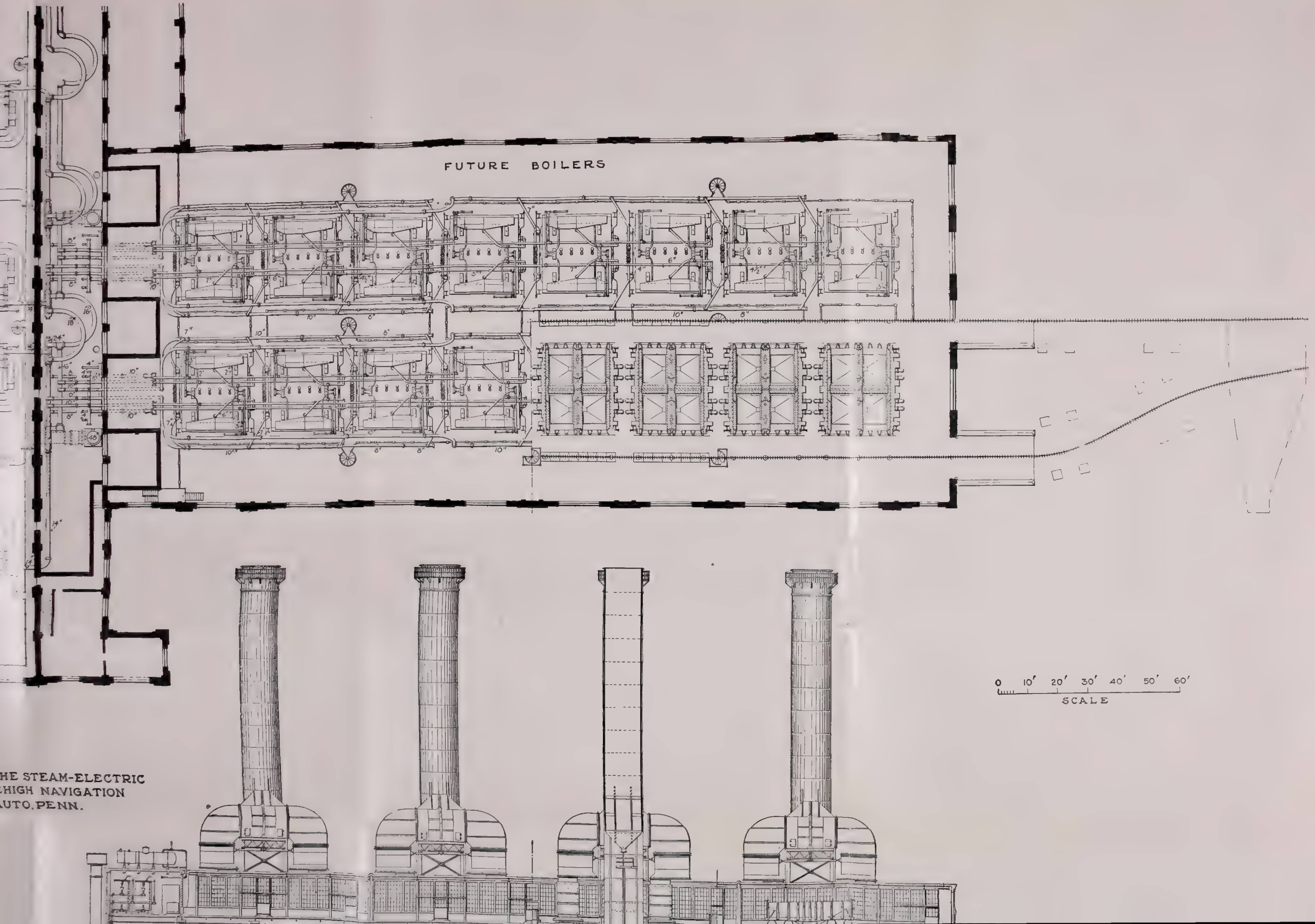


FIG. 22

PLAN AND ELEVATION OF THE STEAM-ELECTRIC POWER PLANT OF THE LEHIGH NAVIGATION ELECTRIC CO., HAUTO, PENN.

ULTIMATE BOILER CAPACITY, AT LEAST 32,000 HP. IN 32 UNITS, AND 100,000 KW. IN TURBINE CAPACITY, EXCLUSIVE OF 25,000 KW. RESERVE. THE PRESENT MAIN EQUIPMENT IS EIGHT 1000-HP. WATER-TUBE BOILERS AND THREE, TEN-STAGE 12,500-KW. TURBINE GENERATORS. THE TURBINE ROOM IS 131 FEET WIDE AND 195 FEET LONG; THE BOILER ROOM IS 68 FEET WIDE AND 285 FEET LONG



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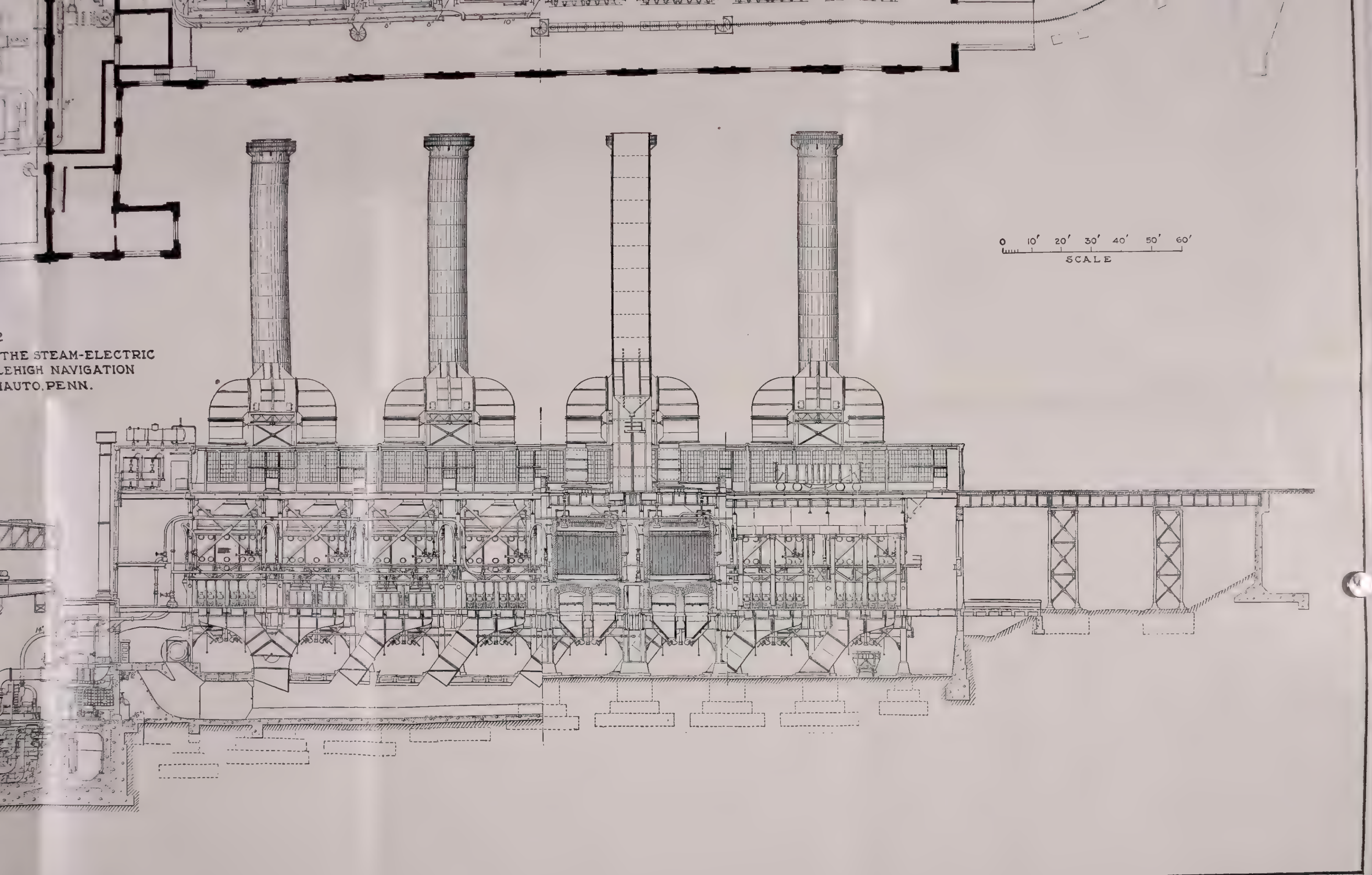

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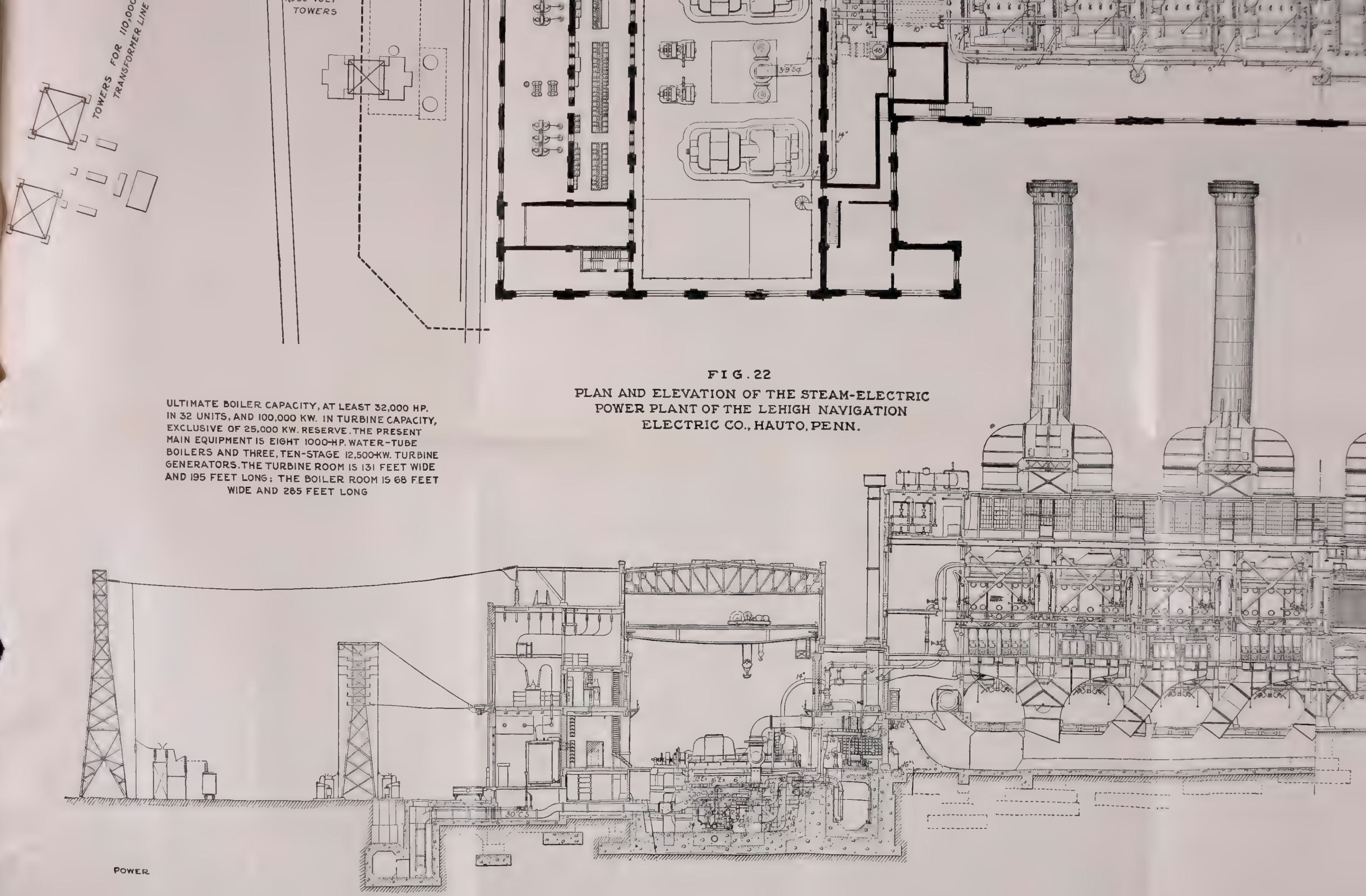
THE STEAM-ELECTRIC
LEHIGH NAVIGATION
HAUTO, PENN.



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Supplement to "Power," June 23d, 1914. Volume 39, No. 25.

All steam for the auxiliaries in the basement is taken from the headers in the header room through two 8-in. mains to an auxiliary header in the pump room. Three 4-in. branch pipes run from this header to the pumps and to the turbine driving the condenser pumps. The 4-in. lines for the condenser-pump turbines are taken from a steam header in the basement, as are also the pipes connecting with the exciter turbines.

All exhaust steam from the auxiliary unit goes to either of two 18-in. main exhaust-steam lines which terminate in an 18-in. header above the boiler-feed pumps and connect with each heater through a tee connection. This header is piped to two 18-in. atmospheric exhaust lines, running vertically through the roof of the header room, the top being 75 ft. above the heaters. The header is fitted with valves so that each heater can use exhaust steam from any battery of pumps or any auxiliary turbine.

The loop plan is carried out on all pipe lines, this provision making it almost impossible for the entire plant to be disabled through an accident to the boiler pipe lines or headers. The high-pressure exhaust steam and hot-water pipes are covered with 85 per cent. magnesia, as are also the feed-water heaters; there are over 50,000 lineal and square feet of this covering in the plant.

The low-pressure pipes of from ½ to 6 in. in diameter are insulated with standard 85 per cent. magnesia covering; the saturated-steam lines of from 2 to 6 in. are protected with two layers of covering; the hot-water lines, 1½ to 6 in., are covered with 1½-in. thick magnesia; the superheated-steam lines, from 7 to 16 in., with 3-in. thick 85 per cent. magnesia and the feed-water heaters, boiler drums, etc., have the same thickness. All flanges and fittings have the same covering as the superheated-steam lines.

All high-pressure steam pipes are drained of condensation by the Holly drip and the open-blow systems; the latter discharges into the exhaust main to the feed-water heaters. All low-pressure lines drain into two sump pits, each automatically emptied by a motor-driven pump, the water being discharged into three tanks on the roof of the boiler house and used as desired for sprinkling the ashes.

PIPING IDENTIFICATION

The color idea carried out on the pipe lines is to paint the flanges the color designating the service for which the line is used. Black is for cold water; bright red, high-pressure steam; dark red, low-pressure steam; yellow, oil; blue, feed water.

The oiling system is piped to a special oil filter in a room on a level with the car track which enters one end of the turbine room. Filtered oil is pumped to elevated oil tanks in a tank room at one end of the boiler room above the boilers. These tanks are cross-connected and serve as reservoirs for the oil used by the plant; the supply pipes run to the various bearings of the units. The oil is handled from the filter to the storage tanks by a 7 and 5 by 12-in. vertical, duplex steam pump.

A traveling crane spans the turbine room 63 ft. 2 in. center to center. The auxiliary hoist has 10 tons capacity, the main hoist 90 tons and the bridge 110 tons; the lift is 147 ft. 11 in. The main hoist motor is of 35 hp., the auxiliary 33, the bridge travel 33, and the trolley transmission 11 hp. capacity.

The fourth and last article of the Hauto plant will deal with the electrical equipment.

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Connections of Compound and Interpole Motors

By F. A. Annett

The connections of a compound motor are not necessarily more complicated than those of a series or shunt machine when the compound machine is viewed as only a series motor with a shunt field winding on it.

To illustrate, consider Figs. 1, 2 and 3, showing respectively the connections of series-, shunt- and compound-wound machines. By tracing out the armature circuit in Fig. 3, which is from the positive side of the switch to the L-connection on the starting box, from the A-connection on the starting box to the A-connection on the motor, and through the armature and field to the negative side of the line as indicated; this is found to be identical with the series-motor circuit, as shown in Fig. 1. Hence, when making the connections of a compound motor, if the armature and series field are connected as a series machine, they will always be right, and all that will be left to consider is the shunt field. If the latter circuit is traced out in Fig. 3, it will be seen to run from the F-connection on the starting box to the shunt field (Sh. F_1) connection on the motor and from the Sh.F-connection to the line; this being identical with the field connection in Fig. 2, which bears out the statement that the compound machine is nothing more nor less than a series machine with a shunt field on it.

Care should be taken to determine which is the series and which is the shunt field on the machine before making the connections, for if the series field is connected in shunt the no-voltage coil will be burned off the starting box or the fuse blown. The series field is always shown on the diagram in heavy lines, while the shunt field is shown in light lines. On all compound motors, except small sizes, the series-field leads are much larger than those of the shunt field. In the small machines, when the shunt- and series-field leads are the same size, the two fields may be determined by testing with a lamp. The lamp will burn brightly through the series field and dimly through the shunt field. After the motor has been connected it is advisable to make a test to determine if the connections have been made correctly. This can be done in the following way:

Disconnect the armature connection on the starting box, likewise the armature connection on the motor, as shown in Fig. 4; then close the switch and move the starting arm to the first contact, as shown by the dotted line. If the connections have been made properly, and the switch is opened or the starting-box arm allowed to drop back to the off position, a severe spark will occur. If there are doubts as to which field has been connected in shunt do not move the starting-box arm upon the last contact, but connect a lamp as shown in Fig. 5. If the shunt field is connected correctly the lamp will burn dimly and a severe spark will occur when the circuit is open. If the series field has been connected in place of the shunt the lamp will burn to full brilliancy and no spark will occur when the circuit is broken.

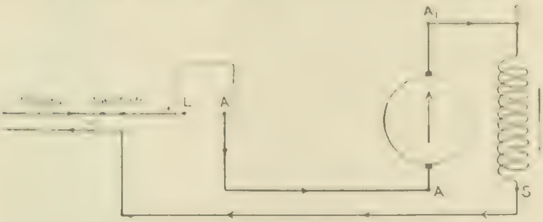


FIG 1

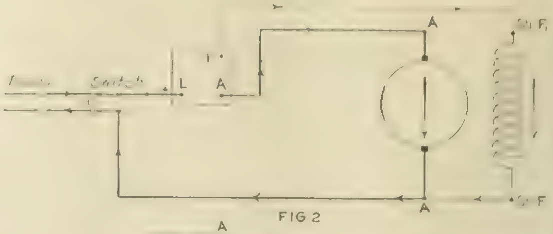


FIG 2

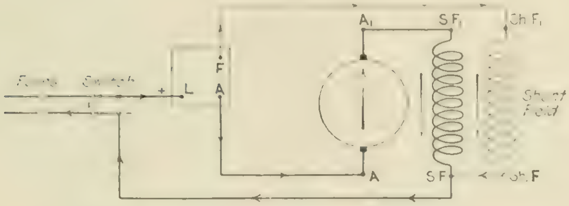


FIG 3

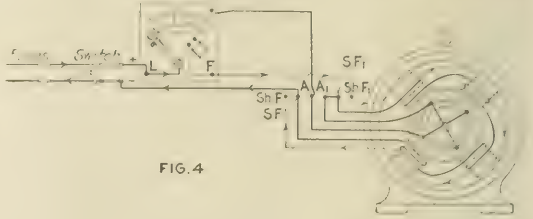


FIG. 4

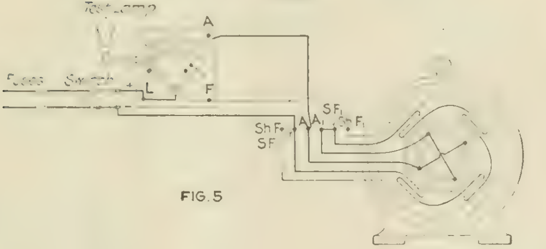


FIG. 5

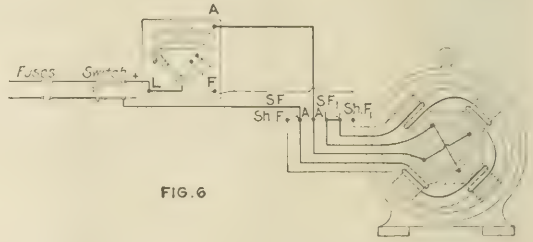


FIG. 6

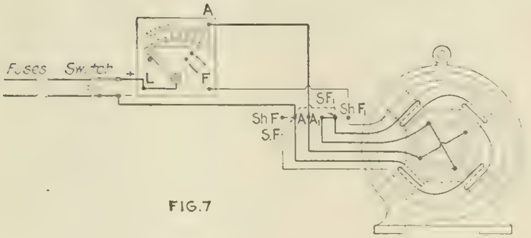


FIG. 7

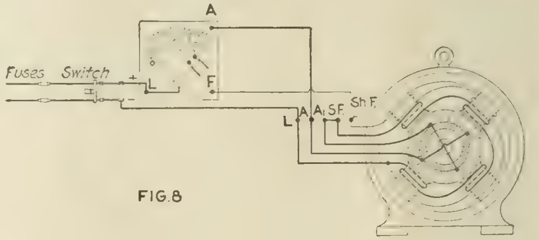


FIG. 8

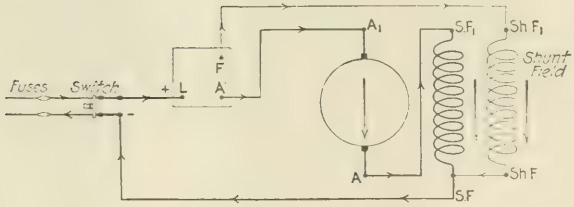


FIG 9

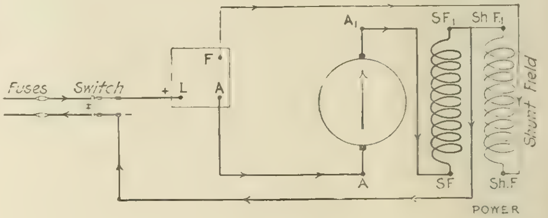


FIG. 10

After the connections have been tested and found to be correct, the next thing to test for is the polarity of the shunt- and series-field coils, which should be the same. To do this, disconnect one side of the shunt field as in Fig. 6, then start the motor as a series machine and note the direction of rotation. *Do not cut out the starting resistance as the motor will reach a dangerous speed.* Stop the machine and connect the shunt field, then short-circuit the series-field connections as shown by the dotted line in Fig. 7 and start the motor again. If the armature turns in the same direction as before, the series and shunt field have the same polarity. If the direction of rotation is opposite to that produced by the series field the series- and shunt-field coils are of opposite polarity. To remedy this, if the shunt field gives the desired direction of rotation, interchange the series-field leads. If the series field gives the desired direction of rotation, interchange the shunt-field connections. The polarity of the series- and shunt-field coils may also be tested by taking the speed of the motor, first as a compound machine, then short-circuit the series field as indicated in Fig. 7 and again take the speed. If the speed increases with the series field short-circuited, the polarity is correct. If the speed decreases, the polarity is wrong.

Series- and shunt-field coils of opposite polarity in a compound motor may produce several effects, depending upon the strength of the series field. It may cause a slight increase only in speed from no load to full load, but in most cases it will cause one of the following effects:

(1) The motor may start and operate satisfactorily under no load. When the load is put on it may suddenly increase in speed and spark badly at the brushes, causing the fuses to blow or throw the circuit-breaker.

(2) The motor may decrease in speed to the point where the fuses will blow, and if not properly fused may stop, reverse and run in the opposite direction; this will be accompanied by severe sparking at the brushes.

(3) The motor may start in one direction and when the starting resistance is partly cut out it will stop, reverse and run in the opposite direction.

(4) The motor may fail to start, the armature usually making slight efforts to turn in one direction and then in the other.

If the series-field coils are of the right proportions, a constant speed will be had from no load to full load. This condition is seldom, if ever, found except in motors designed to accomplish this purpose.

Several of the electrical manufacturers connect one terminal of the series- and shunt-field coils together inside the machine, after first determining the correct polarity of the field coils. This leaves but five terminals coming to the outside, as in Fig. 8, which eliminates the necessity of finding the correct polarity when the machine is connected up.

To reverse the direction of rotation of a compound motor, it is usually best to interchange the armature connections, as in Fig. 9. By comparison with Fig. 3 it will be seen that the direction of the armature current in Fig. 9 is opposite that in Fig. 3, which will cause the armature to turn in the opposite direction.

The direction of rotation may also be reversed by interchanging the field connections where both of the series and shunt terminals have been brought to the outside. Care must be taken to interchange both the series- and shunt-field connections as indicated in Fig. 10. If compared with Fig. 3, it will be seen that the current is in the same direction in both cases in the armatures, but opposite in the field windings.

What has been said in reference to the simple series, shunt and compound machines also holds true for the same class of machines with interpoles. Fig. 11 shows the connections of a shunt-interpole machine The external connections are the same as those in Fig. 2, and the only change in the internal connections is the interpole winding connected in series with the armature. One side of the interpole winding is always connected to one side of the armature, with one armature and one interpole connection brought to the outside terminals.

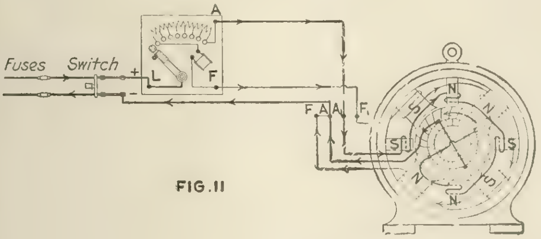


FIG. 11

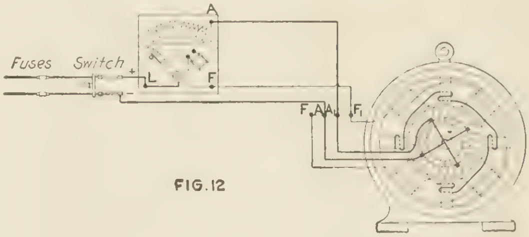


FIG. 12

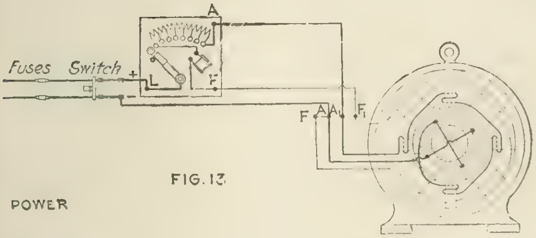


FIG. 13

POWER

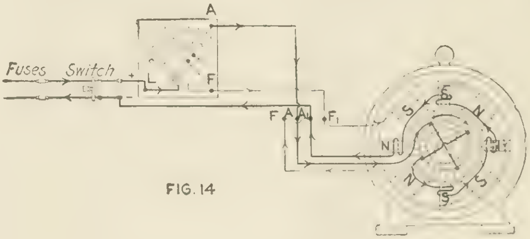


FIG. 14

Care should be taken to have each interpole of the proper polarity, which should be the same as the following main pole. This condition is shown in Fig. 11, for the direction of rotation indicated. Usually, when the machine leaves the factory the interpole winding is connected for the correct polarity; therefore on most new machines this problem is already solved, and the connections can be made to the starter and switch the same as for a motor without interpoles.

After a machine has been taken apart for repairs, unless the connections have been carefully marked, it will be necessary to test the interpoles for polarity when assembling. A practical way to do this is, first, to connect the machine in shunt, as in Fig. 12, and see that it is operating properly, with all the starting resistance cut out. The motor may then be shut down and one side of the shunt field opened. After carefully marking the position of the brushes on the bearing bracket and rocker arm, shift them three or four segments around the commutator; then connect the interpole winding in series with the armature and start the motor again, this time being careful *not to cut out the starting resistance* as the motor will race and may reach a dangerous speed. Note the direction of rotation, and if the armature turns in the same direction as that in which the brushes are shifted, the interpole polarity is correct. If it turns in the opposite direction the polarity is wrong. To remedy this, interchange the armature or interpole connections as shown in Fig. 13 and test the machine again. This time, if everything has been done correctly, the rotation should be the same as the direction in which the brushes were shifted. After the desired condition has been obtained, open the switch and shift the brushes back to their positions and connect up the shunt field to give the motor the desired direction of rotation.

If the interpole is of the wrong polarity, the brushes will spark and burn and the machine will have a marked decrease in speed with an increase in load.

Interchanging the shunt-field connections is usually the easiest way to reverse an interpole shunt motor, although the direction of rotation can be reversed by changing the terminals of the armature circuit, which must include the interpole winding as in Fig. 14. By comparing the direction of the currents in the armature and interpoles in Figs. 14 and 11, they will be found to be opposite, as indicated by the arrowheads.

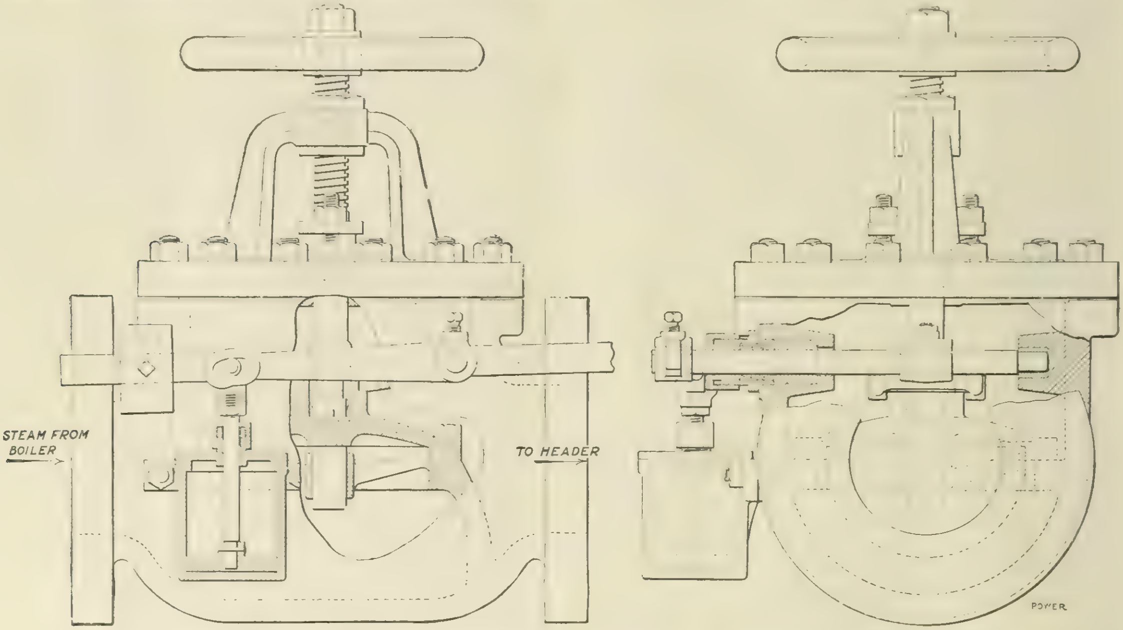
*

Automatic Nonreturn Stop Valve

The illustration shows a 5-in. nonreturn valve which does away with the internal dashpot and piston, the rod of which connects with an outside lever, pivoted as shown. The lever indicates the amount of the valve opening and is a check on the fireman when several boilers are used, showing whether a boiler is producing its proper amount of steam.

The valve, manufactured by the Strong, Carlisle & Hammond Co., 326 Frankfort Ave., N. W., Cleveland, Ohio, is made extra heavy, with an area of 10 per cent. over the pipe size. This excess area eliminates wire drawing or cutting down the volume of steam passing through the valve. All joints are ground, and metallic packing is used in the bronze bearing of the horizontal rod operated by the valve disk. The seat and disk are made of bronze or superheated metal, according to the conditions under which the valve is to be used. The valve stem can be packed under pressure, as when the valve is wide open the bearing ring on the valve stem comes against a ground seat.

The valve disk is in constant motion when the boiler is producing steam, which should avoid any danger of sticking. If the valve is inoperative at any time, it would be shown by the movement of the outside lever. If such a condition does occur, the valve can be put in operation by hand.



Semi-Sectional View of the Strong Automatic, Nonreturn Stop Valve

*

Oil-Engine-Driven Air Compressor

The increased use of low-grade oil fuel for power purposes has led to the design by the Ingersoll-Rand Co. of the oil-engine-driven air compressor herewith shown. This is of the direct-connected, straight-line type with an inclosed frame employing a splash system of lubrication.

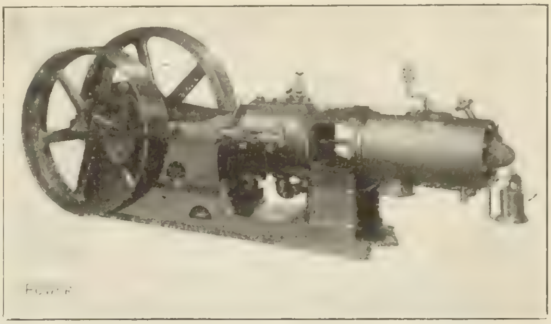
The feature of greatest interest in this machine is the design of the driving end, which consists of a single oil-engine cylinder set behind the air cylinder and directly connected by means of an extended piston rod to the air piston. It follows in general design the hot-bulb type, is single acting and works on the two-stroke cycle. A torch is fitted for heating the ignition bulb preliminary to starting; after the compressor is under way this torch is dispensed with.

Fuel is automatically injected into the combustion chamber by a small pump on the side of the frame, operated by the main shaft. It enters in the form of a finely atomized spray and is immediately ignited by the hot bulb. The stroke of the fuel pump is regulated by a centrifugal governor in the flywheel, thus regulating the amount of fuel injected into the cylinder in proportion to the load. This is supplemented by a regulating device on the intake to the air cylinder.

The operation of this machine is not accompanied by the losses common to the average two-stroke-cycle gasoline engine, in which part of the incoming charge follows the exhaust gases through the outlet ports and is wasted. This is because the fuel is not vaporized by an outside agency and introduced with the air used for scavenging, but is injected directly into the cylinder at the end of the compression stroke. This means that pure air is used during the scavenging period of the stroke; consequently the inlet and outlet ports can be so arranged that more thorough scavenging is afforded without any loss of fuel.

Like a number of the engines of this type, a small quantity of water from the cylinder jacket is injected into the combustion space. This water performs the function of regulating the temperature in the cylinder, thereby preventing preignition. It also reduces the maximum pressure in the cylinder and tends toward making a smooth-running engine. The amount of water injected is regulated according to the load on the compressor.

The combined machine is at present made in only one size with an actual capacity when running at 325 r.p.m. of 66 cu.ft. of free air at 100 lb. pressure and 73 cu.ft. at 80 lb. pressure. The fuel consumption at this speed, and under average operating conditions, is about 2.2 gal. of kerosene per hour. It is adapted to run on either kerosene, fuel oil or distillate. Its weight complete is 3000 lb. and the floor space taken up is 8 ft. 10 in. by 2 ft. 5 in.



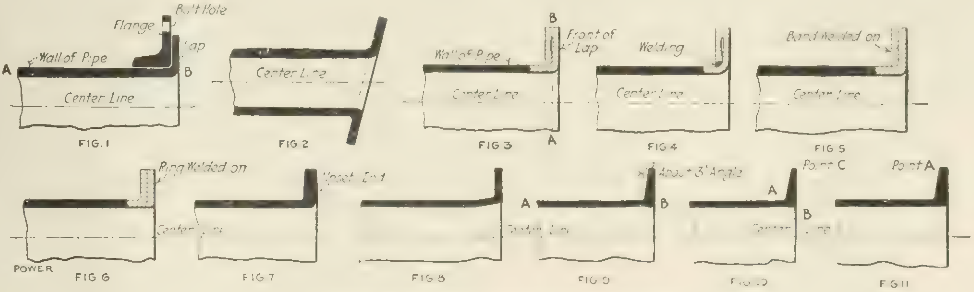
Combined Oil Engine and Air Compressor

* *

Van-Stone Joints

Within the past few years there have been many changes in the design of the joints for piping, and so many so called improvements have been made on the van-stone type that the consulting engineer is confronted with a problem when determining the type of van-stone joint that is best for his requirements.

An analysis of the strains on a van-stone joint under service will show that the stress, due to pressure in the line, will be a circumferential tension, the internal pressure tends to draw the lap back through the flange, which results in a shearing stress along the line *AB*, Fig. 1. Due to structural strains, the stress will be bending, or a tendency to draw the lap through the flange, which would result in the lap being bent at an angle to the axis of the pipe, Fig. 2.



Various Types of Van-Stone Joints

The van-stone joint, one of the strongest possible, is of advantage in the field, as all trouble in aligning bolt holes is overcome, and piping with such joints can be placed in far less time than any other style of flanged joint; if the joint is made properly at the shop the piping system will give satisfaction in service.

The following description of the various styles of van-stone joints may be of interest to engineers in determining the relative merits of each. In making the joint shown in Fig. 3, the end of the pipe is heated, spun out and pressed back upon itself, giving, after machining, a lap thicker than the wall of the pipe. A little consideration will show that the distribution of metal in the lap cannot be equal as the back part of the lap will stretch more than the front; also, it is practically impossible to get a perfect weld along the line *AB*. In some instances, if this type of joint is cut in section, a small pocket will be found traveling around the outer portion of the lap. In time, water of condensation, when the line is cold, will find its way into this pocket. Unless the two laps are absolutely welded the shearing resistance cannot be any stronger than that of the ordinary van-stone joint.

Another type of joint is shown in Fig. 4. The end of the pipe is heated and spun over, and while still hot the lap is forced back upon itself. It is again heated and spun over, and the corner at the back of the lap is welded up. This lap is also thicker than the wall of the pipe when machined. It has practically the same faults as the one shown in Fig. 3, except that water cannot find its way into the pocket formed by faulty welding.

In the joint shown in Fig. 5, a band is welded on to the end of the pipe before van stoning. A ring is welded on to the lap, Fig. 6, after the lap is made. As both joints, Figs. 5 and 6, are makeshifts, the welding for mechanical reasons is rarely if ever perfect, and in the case of Fig. 6, steam will frequently leak through the supposed weld to the periphery of the lap.

The end of the pipe in the joint shown in Fig. 7 is heated and upset, then reheated and spun out in the usual manner, giving a lap thicker, after machining, than the wall of the pipe. Sections cut from this style of joint and given a pulling test have shown that the tensile strength has gone from the average 55,000, to as low as 20,000, and the elastic limit to 10,000 lb. per sq.in. This is, no doubt, due to fiber distortion and crystallization.

The joint shown in Fig. 8 is practically the ordinary van-stone joint, except that the pipe just back of the corner of the lap is slightly funneled out; the flange is also funneled out to meet the pipe. The lap is slightly thinner than the wall of the pipe after machining.

The flange shown in Fig. 9 is as it was originally designed. The pipe is heated and spun out; the lap is slightly thinner than the wall of the pipe after machining; the back of the lap is about 3 deg. from the vertical in order to leave the lap at the point of shear—that is, along *AB*—equal in thickness to the wall of the pipe.

The joint shown in Fig. 10 is slightly upset during the process of spinning out to obtain the square corner, and the thickness along the line *AB* is about one and a half times the wall of the pipe. The thickness at the point *C* is less than the wall of the pipe. Consideration will show that this type of joint is the strongest of all, and gives the greater bearing area for the gasket.

The joint, Fig. 11, is practically the same as Fig. 10, except that the end of the pipe is upset a trifle more, giving a full thickness at the point *A*.

Tests have been made on the ordinary van-stone joint, Fig. 9, which show that it will hold considerably more pressure than the bolts, and with specially designed flanges and bolts it has been proved that the pipe will burst before the lap will be injured. Structural tests for tension compression and bending show that stresses well up to the elastic limit of the pipe must be imposed before any serious damage is done to the lap.

Van-stone joints cannot be made with wrought-iron pipe, owing to the different fiber structure, and steel pipe must be used. The necessary points for a good van-stone joint are that the flange should fit the pipe in the hub snugly, to give support to the pipe to bending stress. For all steam pressures above 150 lb., high-hub flanges should be used. These flanges should be made of rolled steel, forged steel or cast steel on all pipe for pressures above 150 lb. The face of the lap should be machined to give good gasket holding; all scale should be removed from the back of the lap and the flange should have a full bearing against the lap.

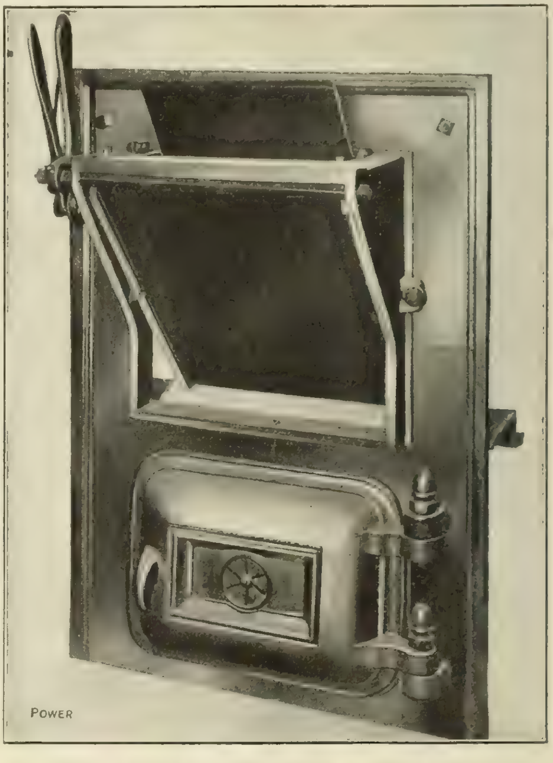
The operation of van-stoning should be done with the pipe at a bright red heat, and the machine used to turn the lap over should be designed to gradually spin the end out and then force the lap back; by this method a better distribution of the metal in the lap is obtained. Many machines simply funnel the end of the pipe out by means of a taper roll, but this method does not allow a proper stretching of the pipe to accommodate itself to the increased diameter of the lap. Facing the lap while hot should not be resorted to, as it frequently draws during cooling, and any irregularity would not be noticed until the pipe is put under pressure. Facing by means of revolving cutters, set radially, does not give a good face, and chatter marks frequently result from this method.

*

McGinniss Safety Fire-Door

For some time the R. M. Eddy Foundry Co., Chicago, Ill., has been making a safety fire-door which opens inward and tends to prevent injury to the firemen in the case of a gas explosion or the rupture of a boiler tube. Formerly this door was mounted inside of the furnace, but for convenience of erection and to add to the life of the door, it is now applied outside and attached to the boiler front by a lug and bolt on the sides. It is thus easy to fit the door to any boiler, new or old.

In the illustration the door is shown mounted on a boiler front made up in the shop. The frame is made of cast iron and the fire-door plate of sheet steel. Guides



McGinniss Safety Fire-Door

bolted to the frame prevent the door from opening outward; the angle at which they are set may be varied so as to close completely the furnace opening. The door is opened by the ratchet handle shown at the left, and will stay in the position at which it is set. A roller secured to the top of the fire-door plate raises the air flap on top of the casting. By means of a dog with several notches, and a pin attached to the flap, the latter is automatically checked and held open until released by hand. The flap admits air over the fire to mix with the volatile and reduce the smoke immediately after firing. If the coal is highly volatile, the fire-door may be set open at any point to admit more air.

The door thus combines the features of safety and smokeless operation. It is simple, and if it ever becomes necessary, the sheet-steel door plate may be replaced by taking out a couple of screws at the top of the casting. Patents for the safety door have been applied for.

⁂

Steamfitters' Drafting Square

Did you ever notice the vertical and horizontal length of a pipe line out of level and out of plumb? This is usually caused by one of the pipes being cut short and then sprung to get it in place.

A device has been patented which, if properly used, will eliminate such faulty work. It consists of a graduated folding square, made with two blades. One of the blades is graduated on both sides and pivoted at the end between the center of a protractor head and the other blade which is graduated on one side only. The protractor is graduated in degrees. On the four edges of the square are marked the standard sizes of 45- and 90-deg. and of flanged and screwed elbows.

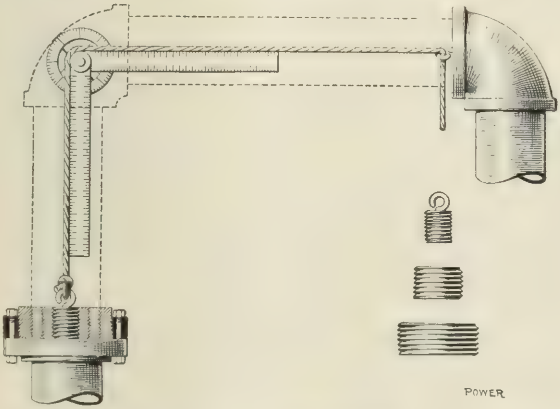


Fig. 1. Square Used for Determining Pipe Lengths Outside of Elbow Fittings

Fig. 1 illustrates how the square is used. If a pipe line is to contain a 90-deg. elbow, plugs the size of the pipe and made for the purpose are screwed into a coupling or flange on the ends of the pipes. On the center of this plug is a hook to which a cord is attached. When properly adjusted and the square is in place, as shown, the cord will be plumb with the center of the vertical pipe and in line with the center of the horizontal pipe. After placing the square it is a simple matter to measure from the end of the pipe line to the marked size of the elbow on the square and, allowing for threads, the proper length of pipe to use is determined.

If it is desired to space a certain number of holes in a given circle, say, in the flange of a fitting, the same device can be used. The inner blade has a slot cut for a trammel to slide in, and is held in place by a nut. The blade is pivoted at the center of the protractor, by a pivot bolt through the center of which is a thumb-screw having a center pointer at the end. When in use, the square is screwed in the flange, placing the pivoting bolt through the center. Then the trammel is set for the given circle, and by revolving the inner blade the diameter is ascribed and then graduated into spaces of 4, 5, 6, 7, 8, etc. If eight holes are desired in the flange, the blade is turned to the point marked 8 on the protractor circle. The trammel is then slid across the circle mark. The design of the device is shown in detail in Fig. 2. It is patented by Thomas G. Tedesco, Peckville, Penn.

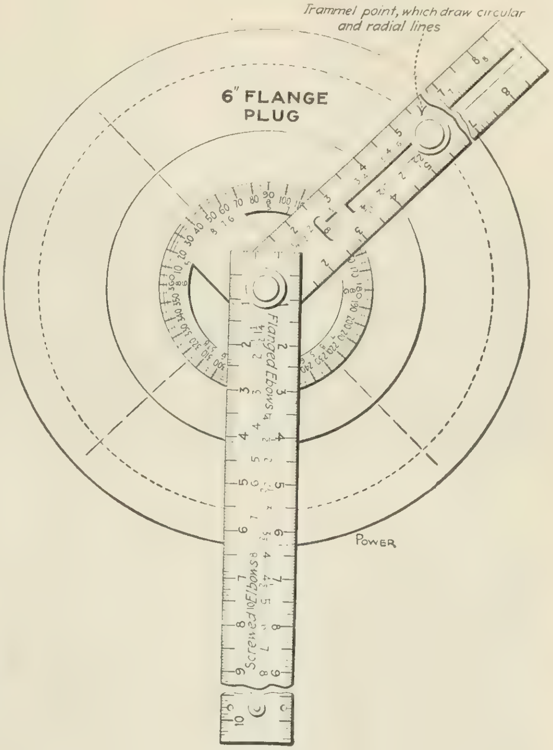


Fig. 2. The Device Used for Scribing Circles and Spacing Bolt Holes

⁂

Cylinder Head Knocked Off—About 3 p.m., Wednesday, June 10, the piston rod of an 11x12-in. Phœnix engine in the Hallenbeck Building, 505 Pearl St., New York City, broke next to the crosshead, allowing the piston to push off the cylinder head as the crosshead returned on the next stroke. The cylinder head faced the wall, and, as no one was injured, the damage is confined to the engine.

⁂

Remarkably Low Fuel Consumption—The recently issued report of A. H. Keene, chief engineer of the Pawtucket Water-Works, credits No. 4 Pumping Station with a delivered horsepower on 1.31 lb. of coal per hour, counting all the coal weighed into the station. The coal per delivered horsepower-hour, based on the pumping coal, was 1.14.

Large Atmospheric Cooling Tower

One of the largest atmospheric cooling towers in this country has recently been installed at the main power house of the South West Missouri R.R. Co., Webb City, Mo. The tower was built by the Mitchell-Tappen Co., New York City, and is of standard steel construction. It is 123 ft. long, 19 ft. wide and 30 ft. high to the walkway, and has a capacity of 2000 gal. per min. cooled from 120 to 80 deg. F. under the mean July atmospheric conditions of the vicinity which are dry bulb, 75 deg. F.; wet bulb, 67.5 deg. F., and relative humidity, 68 per cent.

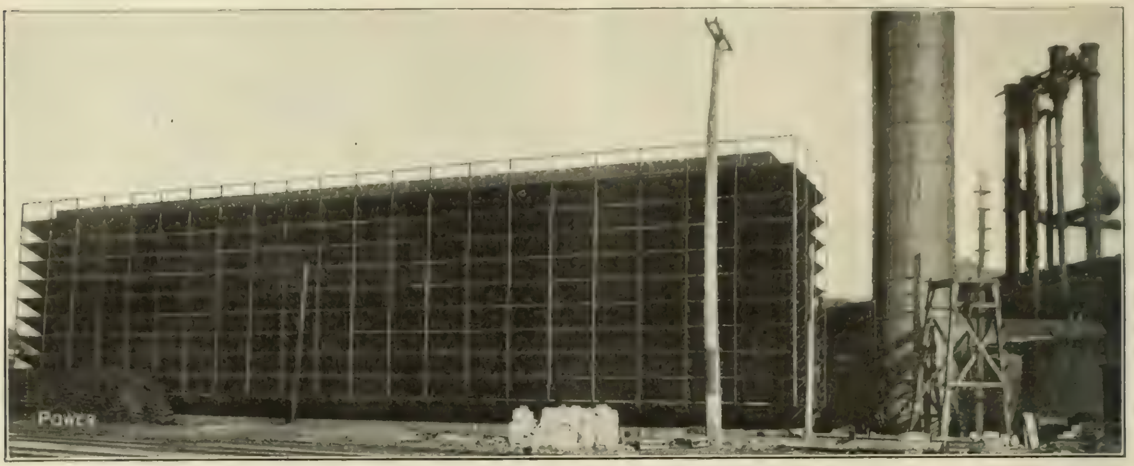


FIG. 1. SIDE VIEW OF LARGE ATMOSPHERIC COOLING TOWER

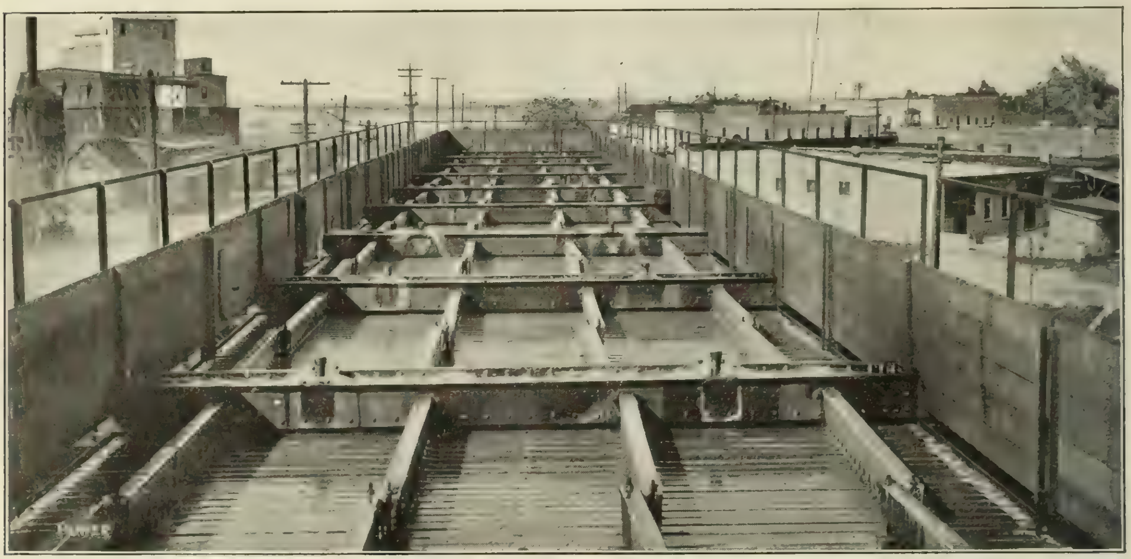


FIG. 2. VIEW OF TOP OF TOWER, SHOWING LAUNDERS AND TROUGHS

These results are somewhat better than that given by the standard formula of the guarantee under which these towers are sold, which is:

$$T_1 = \frac{t + 2t_1 + T}{4}$$

where

t = Temperature, dry bulb or air;
t_1 = Temperature, wet bulb;
T = Temperature, entering water;
T_1 = Temperature, leaving water.

A side view of the tower is shown in Fig. 1 and the top in Fig. 2. The entering water is pumped direct to the top and is carried by branches to the transverse receiving troughs (launders), from which it flows to the distributers. The distributers overflow, the water running over the side and following the surface to the points from which it drops into small semi-cylindrical troughs which make up the distributing deck. These cedar troughs also overflow, dropping the water in a shower on the decks below. The decks or platforms are long, narrow transverse cedar strips or drip-bars, each of which divides the water it receives into two parallel rows of drops, thus producing maximum subdivision. Spaces between the drip-bars allow the water to descend from deck to deck, the alignment of the bars and the width of space being secured by a system of interlocking splines or separators, which unite the separate bars, thus forming a solid and continuous deck capable of resisting warping and twisting tendencies. There are 10 decks, counting the top distributing deck. The spray louvers are of Louisiana cypress tongue-and-groove boards set up tight to a smooth, flush surface.

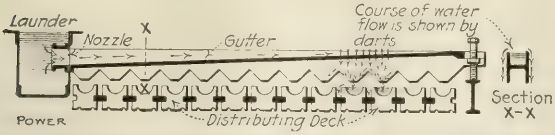


Fig. 3. Section of Launder, Gutter and Distributing Deck

The steel skeleton, braced against wind stresses, and accessible for painting and inspection, consists essentially of a series of vertical lattice girders and horizontal members to which are bolted the decks and louvers.

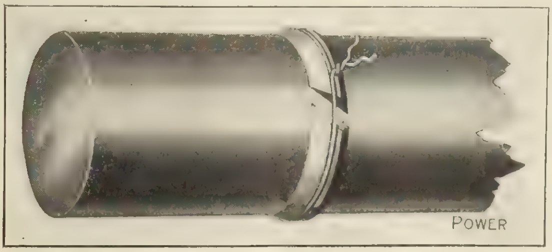
The tower structure is of ample strength, with minimum weight. The foundation is of concrete, combining the anchorage and receiving basin.

Fig. 3 is a sectional elevation of the launders, distributer and distributing deck. The distributer, or gutter, has an inclined bottom, producing a gradually decreasing section as the water travels out, the effect of which is to produce a uniform overflow at all velocities; in addition, there are no perforations, slots or notches to clog and destroy the uniform distribution upon which efficiency largely depends.

The tower has a capacity of about 2400 hp. at reasonable steam consumption and 26 in. vacuum. At present, it is serving approximately 1800 hp. in connection with two barometric condensers.

"Cassco" Packing

"Cassco" is the trade name of a metallic packing made in bar or ring form which possesses the characteristic of expanding when cooling and contracting when heating. This tends to prevent steam or water blowing out when starting a "cold" engine or pump, and as it contracts slightly as the metal expands, due to the heat of the steam, the friction does not increase when the engine is under way. Graphite is mixed thoroughly with the substance of the packing, so that it is self-lubricating, and as it is semi-plastic when warm, there is no tendency to score the rod.

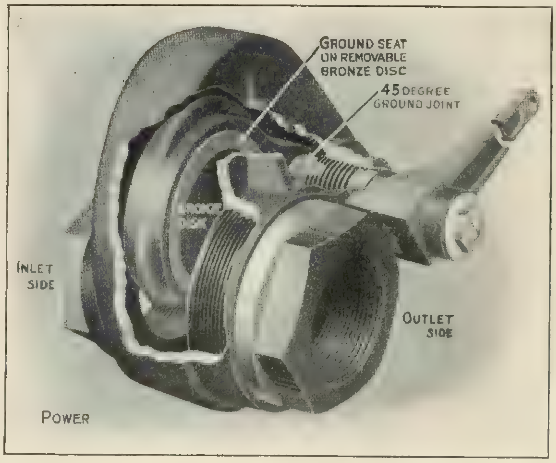


"Cassco" Packing

Cassco rings for air-tight packing are made with the end rings beveled to fit the stuffing-box and gland. The bars are 6 in. long, and of several sizes. They are placed lengthwise in the stuffing-box when it is warm; if the machine is not in use, a blow torch or bunsen burner should be used. The box should be filled with the packing and the gland screwed up hard to compress it into a solid ring. The packing must be kept tight until it sets, when the pressure may be removed. If there is a space around the rod at the back of the stuffing-box the beveled metallic ring shown in the illustration should be first inserted to keep the packing from being squeezed through into the cylinder. Rings of the proper size may also be used and some of the packing added, if necessary, to completely fill the stuffing-box. Cassco has been used with success on all types of engines and pumps and is specially good for machinery handling oil. It is made by the Cassco Bar-Metallic Packing Co., 8 South Dearborn St., Chicago, Ill.

"Okadee" Blowoff Valve

The blowoff valve shown in the illustration has been used on locomotives for years, but only recently has it been placed on the market for stationary and marine boilers by the Engineers Specialties Co., 333 South Dearborn St., Chicago, Ill. It is simple, has seven parts, is quick opening and has a straight through blow for sediment and water.



"Okadee" Blowoff Valve

The valve itself is a removable disk made of gun-metal bronze, carried loosely in a yoke secured to the stem to which the operating handle is attached. The disk seats against the inner face of the hexagon nut shown in the foreground and on the opposite side against the valve body. A movement of the handle carries the yoke and the disk across the face of the opening, and when the valve is fully open the outlet is cleared. The disk is free to turn and reseat in a different position at every closing. To take out the disk it is only necessary to unscrew the hexagon nut on the outlet side. The body is of gray iron, the yoke of cast steel, the disk of gun-metal bronze, the stem of machine-tool steel and the bushing for the stem of brass.

Centrifugal Effects in Belting

By W. F. Schaphorst

Despite the fact that thousands of successfully operated slack belts are daily staring them in the face, scientists refuse to unbend to the everyday practicability of such belts. "It is written" in engineering proceedings that belts, to operate properly, must be given initial tension.

The writer admits that hard, stiff, uncared-for belts need initial tension, but belts should not be hard, stiff and uncared for. They should be made pliable, for it is acknowledged even by scientists, that in the pliable state belts are best qualified to grip the pulleys closely and they grip the pulleys to such an extent that extremely slack running is often possible. An instance has been called to my notice where a 16-in. painted canvas belt, running at a speed of 2340 ft. per min., is transmitting 300 hp. and running 30 in. slack. The computed pulling stress on this belt is therefore about 264 lb. per in. of width—an extremely high tension under any condition

Another instance has been called to my notice where a belt tightener, listing at nearly $1000 and carrying a probable discount of 40 per cent., was used to create tension on a drive where one pulley was small and the other large. The belt was old and oily. Even the tightener did not prevent slip. A man who has had considerable belt experience was consulted. He recommended making the belt pliable, not necessarily sticky, and in a short time, after his directions had been followed, the slipping stopped. And, what is more important still, the idler is no longer needed. The belt sags 13 in.

The chief advantages of slack belts as has often been pointed out are: Increase of arc of belt contact, and decrease in bearing friction. One argument against these belts is that serious centrifugal tension is always present where speeds are high and pulleys small, and it seems that no one has ever raised a finger to refute this argument to any extent. The slack-belt enthusiasts and operators merely say when asked to explain, "Well, our belts are running, aren't they? And they run at mighty high speeds, too, without slipping, let me tell you. The proof of the pudding, etc." Elimination of slip is, of course, of greatest importance.

Centrifugal force is computed from the formula

$$C = \frac{WV^2}{gR}$$

where

W = Weight in pounds;
V = Velocity in feet per second;
g = Gravity;
R = Radius of curvature in feet.

Centrifugal force is, therefore, greatest at the smaller pulley, belt velocity being the same at all points.

Fig. 1 shows a proportion commonly observed in practice, namely, a 4-ft. driving pulley, a 1-ft. driven pulley and 20 to 25 ft. between centers. The lower half of the belt is the pulling half and the upper half is the slack or nonpulling side.

Where the nonpulling side is permitted to run slack, about as shown in Fig. 1, the weight of the belt alone, hanging in the form of a catenary, will compensate for the centrifugal force up to a considerable speed in most cases, but as soon as that speed is passed the belt mathematics we are customarily fed tells us that to overcome this high centrifugal tension, more tension must be added to the nonpulling side by drawing the shaft centers farther apart. Nothing is said about the radius *R* of the slack side just before passing onto the small pulley.

The tendency to "fly away" from the large pulley is seldom if ever serious at present-day speeds. The formula above tells why. The weight of the belt alone is great enough to pull itself down below the tangent line *TT* in which case a curve concave upward is formed between the pulleys, the inertia property causing the sharpest curvature to form close to the small pulley, thus increasing the arc of contact considerably more than when the belt is not in motion, and creating a counter centrifugal force that can be accurately computed as soon as we know the curvature at the sharpest turn. If this "slack curvature" is equal to the curvature of the small pulley we are justified in assuming that the ill effects of centrifugal tension are eliminated.

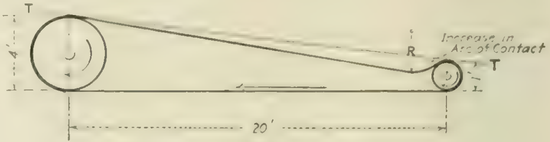


FIG. 1

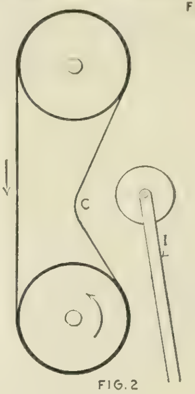


FIG. 2

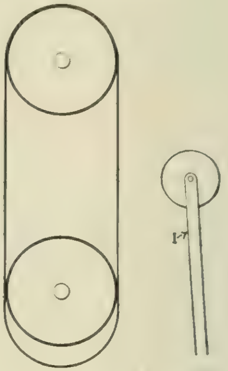


FIG. 3

It has long been known that a slack curve once established in a vertical or approximately vertical belt, running at high speed, will maintain its form about as indicated in Fig. 2 and pull full load with apparent ease. It is the centrifugal force set up in the curve *C* that holds the belt in running position. As soon as the engine stops (usually before it stops) the belt drops to the position shown in Fig. 3. To start the drive, idler *I* must be used.

It would appear then that the scientific way to adjust the slackness of a slack belt is to make the loose curve as sharp as possible while the belt is in motion, and close to the small pulley. If the curvature can be made sharper than on the small pulley, all the better.

This, the writer believes, explains why slack belts are so successful at high speeds.

* * *

The "Aquitania," latest of the Cunard liners, requires a force of 339 men to handle her power equipment. Counting the chief, there are 35 engineers, 168 firemen, 16 leading firemen, 100 coalpassers and 20 oilers. This is more than one-third of the total crew.

Editorials

Repair Supplies

The cartoon this week, while lacking in "bones," is full of "meat."

Particularly apt, we think, is the application of the Old Mother Hubbard nursery ryhme to the situation found in so many plants. The engineer knows the needs and would like to supply them, but can't, and so the power plant goes hungry. If those whose business it is to provide the "bones," those responsible for the management of plants, all appreciated the importance of keeping the repair supplies "cupboards" filled, the engineers would never find them "bare."

Another familiar old jingle is the one that shows how "for the want of a nail," "a kingdom was lost." It is no exaggeration to say that for the want of some very inexpensive supply parts, important pieces of plant equipment have gone to rack and ruin. Worse than that, accidents have happened that resulted in loss of life and property which could have been prevented had the proper repair supplies been available.

When we urge that the power-plant repair locker should not be allowed to get into the depleted condition represented in the cartoon, we mean it to apply not only to expendable supplies, but to tools, for a suitable kit of tools belongs in the locker when not in actual use. To be shy of either tools or supplies is usually a policy of saving pennies and wasting dollars. A high-priced packing, for example, may be used where another, costing much less, would answer as well or better. Inversely, a low-grade packing may be applied on a high-speed piston in the absence of a suitable kind, which will ruin the rod or cause a shutdown, the far-reaching effect of which is hard to estimate.

The engineer cannot be expected to keep his plant in the best condition without tools and supplies. The value of the extra time on one job, in many instances, will be greater than the cost of suitable tools, even if they were thrown away after once using.

In many plants, the scrap pile is depended upon for pipe-line material, such as fittings, valves and even pipe lengths. An extension of piping made up from such junk is very apt to develop leaks in the fittings and pin holes in the piping. Here extra gage glasses are unknown; pump and engine packing is missing, and consequently odd sizes are cut down to fit the valve stem or piston rod.

Following are instances of neglect of the kind we deplore: One lighting plant contained three generating units, using eight wire-mesh copper brushes each. There was no reserve stock and new brushes were bought only six at a time, not enough for one machine.

Think of this as actually happening! An engineer, unable to obtain the proper piston-rod packing, made his own packing from the lower extremity of his work shirt and tallow. It stopped the steam from blowing nearly to the crank, although, of course, it was short-lived.

Such little things as valve disks are lacking in many plants when wanted, due to the "penny-wise-and-pound-foolish" policies of the management.

In a certain plant, the blowoff valve (there was but one) of a boiler began leaking so badly that it was difficult to keep the proper water level, and finally the boiler had to be cut out of service for the remainder of the run. The disk was cracked and broken, and had been for some time, but there were no disks on hand. The boiler had to be operated, and consequently the management was forced to purchase a few disks.

No argument is needed to show that such conditions are all wrong. It is generally thoughtlessness or carelessness that is responsible.

The needful thing is to get those who must pass on the engineers' requisitions for supplies to appreciate that a good stock is not an extravagance, but a real investment. With the plant kept up to the best condition, it will operate most economically. "A stitch in time saves nine," and a little repair made as soon as it is needed will forestall a costly overhaul when the seed of neglect sprouts into a breakdown. A third profit is a larger realization on the expenditure for plant help. Given the facilities, the engineer and his assistants will gladly do many little things that would run into money if outside labor were employed to do them.

⁂

Monuments of the Seas

It is a far cry, back three centuries, to the time when Hudson sailed the "Half Moon" up the river that bears his name. Two centuries later the steam-propelled "Clermont" followed the course of the "Half Moon" up the stream now agitated by many craft of commerce.

Like a pebble dropped in a lake, these marine wonders of their days have gone, and little more than pages of history remain to tell of their existence, the memory of them fading like the ripple where the pebble dropped. As these craft disappear over the horizon of Time to make history, new maritime wonders appear.

Thrillingly the daily press now tells of how the "Vanitie," a racing yacht contesting to defend the cup in the coming races, tore over ten miles of sea in the short time of one hour, sixteen minutes and fifteen seconds—not quite eight miles in an hour is the best that can be done by the finest example of sailing craft that yachtmen can produce. The "Aquitania," breaking all records for a maiden voyage, exceeded the guaranteed speed of twenty-three and one-half knots (twenty-six and one-half miles) an hour, over three times as fast as the "Vanitie," and kept it up over the three thousand miles of sea separating the ports between which she plies.

It is power, steam power, that makes this difference possible—a higher development of the same forces that drove the old "Clermont" up the Hudson at a speed that would shame the skipper of a towing tug. It is steam power that makes the trips across the oceans matters of a few days instead of months. It is power that gives to the passenger the benefits of electric light, of well ventilated quarters; that preserves his foods and makes wireless telegraphy a commercial success.

Truly, these modern palaces of the seas are monuments to the engineering skill that designs and manages them.

⁂

Municipal Isolated-Plant Scheme Relinquished

At Springfield, Mass., it was proposed to install a municipal isolated electric plant for the city buildings in the urban center. After serious consideration, the United Electric Light Co. has offered to supply current at four cents per kilowatt-hour as against the seven cents previously charged. This saving to the city is estimated to be $7500. Curiously, this four-cent rate only applies to a few of the city's buildings while the others are still charged the seven-cent rate. Why? Probably no plant was *proposed* for these other buildings. Would it not be the part of good tactics to *propose* a plant for the remaining buildings now, and secure a reduced rate for them also? It looks like easy money.

Incidentally, it would be interesting to know just how far the *proposing* had to proceed before the company "came across" with its reduced rate, and also what new equipment or efficiency engineering makes it possible to sell this particular part of the company's output at a rate lower than before. One rate or the other must be perforce juggled.

Contracts for electric service are sometimes fearfully and wonderfully made. For example, one of the terms of the contract under which the Federal Government in the District of Columbia gets current during six months of the year (April to September inclusive), at the rate of two and a half cents per kilowatt-hour *in buildings having their own generating plants,* provides that should those same buildings require any street service whatever during the remaining six months they will pay six cents for it (up to a certain amount used) and also at the rate of six cents for *all current used* at the two and one-half-cent rate during the fiscal year.

In other words, suppose $5000 worth of the two and and one-half-cent current had been used, and it was desirable to use street current for a short time during the winter, there would be due the company by the terms of this contract $7000 back pay *in addition* to the amount of the bill for the winter current at six cents. This contract is in force at the present time.

⁂

Power-Plant Economics

At various times Power has warned against getting in a "rut" in the managing of the plant. This "rutty" habit still prevails to a large extent and not in the small plants alone. In the large, well equipped station, where one would expect to find plenty of initiative and "go," it is the rule to find routine paramount to all else; that routine is mistaken for watchfulness.

Ask the man in charge of the boiler plant how many boilers are necessary to carry a certain load most economically, and you will often receive a vague and unsatisfactory reply. Inquire as to the percentage of CO_2 in the stack gases under certain load conditions, and you will probably receive a similar answer.

Look up the chief and ask him about the scale in the boilers. Find out if he has a full understanding of the heat losses possible through the presence of scale in the boilers. He will acknowledge that the loss is large, but generally he can only guess as to just *how* large it is. Of course, the boilers are cleaned at regular stated intervals; that is part of the routine. The scale is removed from the boilers and—what more can one expect? At the same time, it will probably be noticed that there is no means of treating or softening the feed-water supply and no one on the job capable of directing feed-water treatment. So the boilers are allowed to remain in service for a certain length of time, and then they are cleaned.

At many plants throughout the country at least two per cent. of the fuel consumed could be saved merely by treating the boiler-feed water and so reducing the amount of scale in the boilers. A plant burning five hundred tons of coal per day, for instance, could save ten tons every day, which in a year would represent quite a sum. The power-plant operatives are not to be criticised for existing conditions. They are going about things in the conventional manner, doing things the same as they have always been done, in the same way that they would be done in the plant next door.

Often it is the owners, and those in charge of the management, who are directly responsible for the losses which are continually taking place through their neglect to supply men capable of exercising technical control of these features of power-plant operation. And for the reason that the technical man demands, and receives, a just compensation for his services.

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When the fireman says, "Boss, what percentage of CO_2 do you want today?" watch out that the steam doesn't go down just when you need it most—and don't fire the fireman. He knows his business.

⁂

Jack London tells of a cook that was fed to the sharks because he wouldn't keep himself clean. Well, how about the fellow who lets the flue fill with soot until there isn't draft enough to carry the load?

⁂

If there's anything a man should be called down for, it's letting steam blow out of the back-pressure valve at the same time the live steam is blowing into the heating system.

⁂

Some engineers think you don't need a separator on a superheated steam line. Bet they never listened much when they started the unit on the line. Sometimes it sounds like a man gargling his throat.

⁂

Waxing enthusiastic over the report of the Committee on Progress of the National Electric Light Association, a metropolitan daily says, "Although steam had centuries the start, electricity already yields one-fourth the industrial power of the United States, and the prediction is made that it will rapidly yield over four-fifths, forcing steam into the background." Let the "dailies" remember that, neglecting water power, for every horsepower output increase of electricity, there is more than a horsepower increase in steam somewhere. Electricity must be generated; it does not grow like weeds.

Engineers' Study Course

Elementary Mechanics—XIV

Last Lesson's Answers

56. There are two ropes passing over the pulley *A*, Fig. 51, and the tension in each rope is 80 lb. Hence the weight that could be placed on the pulley *A* would equal

$$80 \times 2 = 160 \ lb.$$

57. Since there are four sheaves on the movable block, Fig. 52, there would be 4 × 2 = 8 ropes passing over the movable pulley. The pull in each rope is 100 lb. Therefore, the weight *W* would equal

$$8 \times 100 = 800 \ lb.$$

58. There would be five sheaves on the fixed block as will be evident from a careful inspection of Fig. 54 where for the sake of clearness the sheaves are made of varying diameter. The rope is attached to the movable block at the point *A*, passes over the first sheave *B* of the fixed block, thence to the sheave *C* of the movable block and so on until the rope leaves the last sheave *D* on the fixed block. There are nine ropes supporting the movable block and hence the weight *W* equals

$$9 \times 100 = 900 \ lb.$$

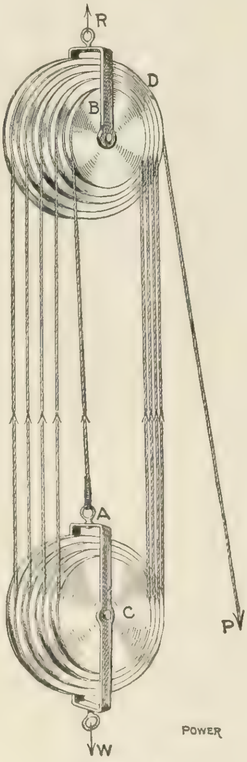


Fig. 54.

59. In problem 57 the reaction *R* on the hook equals the sum of the weight *W* and the effort *P* or

$$R = 800 + 100 = 900 \ lb.$$

In problem 58 the reaction *R* on the hook is

$$900 + 100 = 1000 \ lb.$$

60. From equation (20)

$$W = \frac{2 \times P \times R}{(R - r)}$$

where

$P = 100$ lb.;
$R = 8$ in.;
$r = 7$ in.

Hence

$$W = \frac{2 \times 100 \times 8}{(8 - 7)} = 1600 \ lb.$$

Friction

When an attempt is made to slide one body over another a certain resistance is encountered which must be overcome before the body will move. This force which tends to prevent the motion of one body on another is called the *force of friction* or simply the *friction* between the bodies. The amount of this friction will depend upon the nature of the surfaces in contact, and the materials of which the bodies are made. No matter how smooth or regular the surfaces in contact, this force of friction will always be present to counteract the forces tending to move the bodies. Thus in Fig. 55 let the body *A* weighing *W* pounds rest upon a table. Attached to the weight *A* is a cord passing over the pulley shown. Let the force *F* be increased until the body *A* is just on the point of moving. It must be evident that the horizontal pull in the cord is equal to the force *F*, and hence the resistance between the body *A* and the table is equal to the force *F* and acts in a direction opposite to this force.

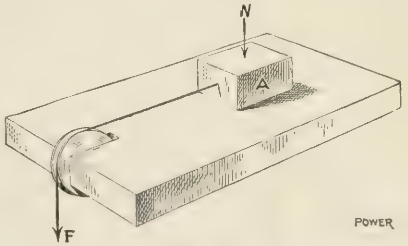


Fig. 55.

The *force of friction will always act in a direction opposite to that in which the body tends to move.* When the body *A* is just on the point of moving the force *F* is called the *limiting* or *static friction* between the body and the table. The force required to keep the body in a state of uniform motion is found by experiment to be less than the force which is required to put the body in motion. However, when the body is once in motion the force of friction between the body and the table is called the *sliding friction* and in all cases this will be less than the static or limiting friction.

In Fig. 55 it will be noted that the weight *W* is acting at right angles to the direction of motion of the body *A*. *The force or pressure which acts at right angles to the direction of motion of a given body is called the normal pressure between the given body and the surface over which it tends to move.* The greater this normal pressure the greater will be the friction between the given bodies, and the greater will be the force *F* required to move the body *A* in Fig. 55.

The ratio between the force of friction, or the force which is just great enough to put a given body in motion, and the normal pressure is called the *coefficient of friction of rest.* Thus, let

F = Force required to put the body in motion;
N = Normal pressure between the given bodies;
f = Coefficient of friction of rest.

Then from the above definition

$$f = \frac{F}{N} \qquad (21)$$

or

$$F = f \times N \qquad (22)$$

If a force of 50 lb. will move a weight of 200 lb. the coefficient of friction f will equal

$$\frac{F}{N} = \frac{50}{200} = 0.25$$

If, in equation (21), F represents the force that will produce uniform motion of the body A along the table, then the value of f will be called the *coefficient of friction of motion*, and this is the value commonly given in tables.

A simple apparatus for determining this coefficient is shown in Fig. 56, which consists of a smooth plate CB of a given material, on which is placed a body A of some other material. The wedge D is forced under the plane CB until a slight tap on the weight A starts it down the plane with *uniform motion*. The angle BCX = angle a is then carefully measured. Let the line RS represent to scale the given weight W, and let this weight be resolved into two components RT and TS, the former being at right angles to the plane CB and the latter being parallel to the plane. The effective force causing motion down the plane is therefore the component TS, which is the force of gravity acting parallel to the plane. The component RT causes no motion, but is the normal pressure between the weight W and the plane CB. This normal pressure N produces a force of friction F which acts parallel to the plane and tends to hold the body A at rest. Now from equation (22) the force of friction F is equal to the product of the coefficient of friction times the normal pressure N. For equilibrium to exist the force of gravity G acting down the plane must equal the force of friction F, which is acting up the plane or $F = G$. The angle SRT is equal to the angle BCX or the angle a, since the line RT is perpendicular to the line CB, and the line RS is perpendicular to the line CX. Also the component $TS = W \times \sin a = G$ and the component $RT = W \times \cos a = N$. Therefore, since $F = G$,

$$W \times \sin a = W \times \cos a \; xf$$

or

$$f = \frac{W \times \sin a}{W \times \cos a} = \tan a \qquad (23)$$

[Note—The sine of an angle divided by the cosine of the angle equals the tangent of the angle. See the lesson, Trigonometry—III, Dec. 9, 1913.—Editor.]

Hence the coefficient of friction f is the tangent of the angle a at which the plane CB must be inclined to produce uniform motion of the body A down the plane. The angle a is called the *angle of friction*. The force of friction F is practically independent of the area of the surfaces in contact.

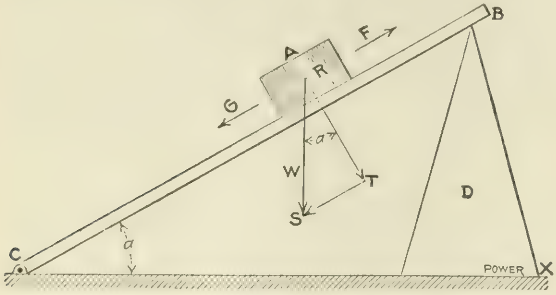


FIG. 56.

STUDY QUESTIONS

61. A cast-iron body weighing 200 lb. rests upon a horizontal steel plate. If the coefficient of friction is 0.28, what force will be necessary to move the casting?

62. Is the force necessary to raise a body from the ground the same as the force required to move the body along the ground? Give a reason for your answer.

63. During a given experiment with the apparatus shown in Fig. 56 the angle a was found to be 15 deg. What was the coefficient of friction between the plane and the body A?

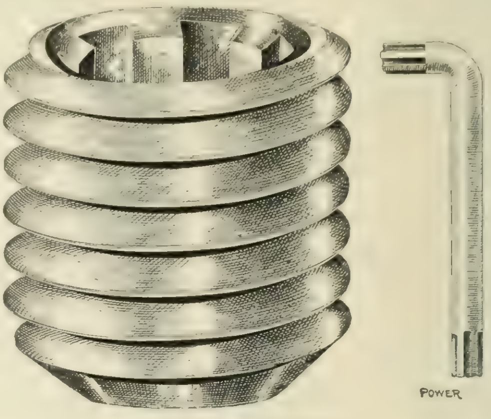
64. A railway car weighing 60,000 lb. requires a force of 600 lb. to keep it in a state of uniform motion along a horizontal track. What is the coefficient of friction between the wheels and the track, neglecting the friction at the journals?

65. At what angle would it be necessary to incline a given plane so that a given body whose coefficient of friction was 0.3 would move down the plane with a uniform speed?

⁂

Bristo Safety Setscrew

The accompanying illustration is a view of the Bristo safety setscrew and the wrench for setting it up. The hollow head is equipped with six dovetailed slots, into which corresponding projections of the wrench fit. When the setscrew is set up there is no tendency for the wrench to expand or split the screw, but there is for the wrench to contract ahead on account of the angles of the face of the dovetailed flutes. As the setscrew, when in place, does not project above the hub of the pulley, etc., it thus eliminates a source of danger to the workmen.



SAFETY SETSCREW

This setscrew is manufactured by the Bristol Co., Waterbury, Conn., and is made in sizes from ¼ to an inch in diameter, with U. S. standard threads, for all stock sizes, and can be furnished in sets of round, flat, conical and dog point, instead of the cup point shown.

⁂

Globe Valves for Superheated Steam in Europe—Some time since, "Power" was called upon to verify the statement that globe valves were exclusively used for superheated steam in Europe, on account of the liability to distortion of gate valves with the high excessive changes in temperature. We referred the question to Dr. ing. h. c. Wilhelm Schmit, the eminent authority upon superheaters, and are advised by him that "In Germany globe valves have always been used nearly exclusively for saturated as well as for superheated steam. The use of gate valves for this purpose has been quite exceptional. So far as I know, other European countries follow the same practice. I do not know of any bad experiences with gate valves, as I do not know of any case in which this gate has been used with superheated steam. Over here, gate valves are used for the most part only in connection with water, gas and exhaust-steam piping."

Tests of the Taylor Stoker in Moderate Sizes*

BY HORACE JUDD

Much is being said about the high overload efficiency to be expected from the underfeed type of mechanical stoker, and the results of a number of carefully made tests have been presented to the public during the past few years showing remarkable efficiency and economy for this type of furnace.

The trials thus reported have, for the most part, been conducted under favorable conditions, with the boilers and furnaces often of unusually large sizes, which have been operated under expert guidance. In view of this, it has frequently been a query with interested power-plant men whether the stoker in units of moderate size would give the same favorable showing when tended by the average fireman.

During the past year the writer has had an opportunity to make a series of evaporative tests on a 250-hp. Babcock & Wilcox boiler and a 300-hp. Flanner boiler, each equipped with a three-retort Taylor stoker. Four different kinds of coal were used and the only instructions to the firemen were to run the furnace and boiler as usual and as if no boiler trial were in progress.

TABLE 1. AVERAGE DATA AND RESULTS OF EVAPORATION TESTS

1 Kind of furnace—Three-retort Taylor Gravity Underfeed Stoker										
2 Kind of boiler—Babcock & Wilcox Cross-Drum, Water Tube							Flannery, Cross-Drum, Water-Tube			
3 Grate surface—41 sq.ft.							45 sq.ft.			
4 Heating surface—Boiler 2485 sq.ft. Economizer 2040 sq.ft.							3130 sq.ft.			
5 No. of trial	1	2	3	4	5	6	7	8	9	10
6 Date	3-20-13	3-21-13	3-22-13	3-24-13	3-25-13	3-27-13	4-9-14	5-18-14	5-22-14	6-2-14
7 Duration, hr.	10	10	10	10	10	10	10	10	10	10
Average pressures										
8 Barometer	29.01	28.58	29.74	29.08	28.89	28.94	29.46	29.82	29.32	29.55
9 Boiler gage	96.8	96.5	96.0	99.7	97.6	99.5	123.8	115.1	118.3	123.8
10 Tuyere box	1.50	1.45	1.30	1.80	2.42	1.90	1.48	1.66	2.76	
11 Draft over fire	0.125	0.09	0.16	0.15	0.16	0.19	0.045	0.03	0.038	0.023
12 Draft leaving boiler	0.32	0.12	0.34	0.31	0.39	0.44	0.24	0.25	0.32	0.34
13 Draft entering economizer	0.71	0.73	0.74	0.74	0.89	0.75	....	....	....	....
14 Draft leaving economizer	....	0.78	0.81	0.80	1.10	1.14	....	....	....	....
Average temp.										
15 Fire room	88	84	78	80	87	76	71	94	96	95.5
16 Flue gas leaving boiler	745	705	664	711	710	657	450	466	485	664
17 Flue gas entering economizer	541	501	508	543	530	507	. .	. .	.	. .
18 Flue gas leaving economizer	274	271	269	278	265	249	. .	.	.	.
19 Feed water entering economizer	147	144	140	145	134	121	....	. .		.
20 Feed water leaving economizer	170	169	180	171	165	157	....			
21 Feed water entering boiler	162	161	170	160	152	143	54	192	69	75
Analysis of Coal as fired	West Va. Splint		Hocking		Pitts. No. 8		West Virginia Fairmont District		West Va. Thacker Coal Field Washed	
Grade	Nut, pea and slack						Nut and pea			
22 Moisture	4.42	4.66	9.40	11.62	6.31	3.79	6.31	3.90	2.73	6.09
23 Carbon	70.74	64.48	63.25	60.23	66.57	69.21	66.39	71.59	71.95	70.47
24 Hydrogen	5.10	4.98	5.16	5.21	5.22	5.12	5.01	4.98	4.87	5.42
25 Oxygen	11.49	11.46	17.13	18.69	12.31	10.33	13.76	9.93	8.93	12.90
26 Nitrogen	1.31	1.27	1.19	1.12	1.16	1.21	1.10	1.14	1.14	1.49
27 Sulphur	1.06	1.58	1.08	0.85	3.64	3.56	2.79	2.42	3.36	1.10
28 Ash	10.30	12.33	12.19	13.90	11.10	10.57	10.95	9.94	9.75	8.62
28A Combustible in refuse	19.19	29.89	22.77	17.57	25.89	28.55	25.50	41.50	48.53	22.89
29 Unburned coal	2.73	5.94	5.34	3.44	4.30	4.70	4.21	7.83	10.17	....
30 Heating value, coal	12,697	12,375	11,164	10,570	12,067	12,582	12,184	12,830	13,120	12,744
31 Heating value, combustible	14,889	14,890	14,244	14,191	14,625	14,692	14,700	....	14,980	14,950

LOCATION OF PLANTS

Six of the trials were conducted in March, 1913, on a 250-hp. Babcock & Wilcox boiler of the cross-drum type forming the boiler equipment at the Troy Laundering Co., Columbus, Ohio; and three of the trials were made on a 300-hp. Flanner boiler also of the cross-drum type, at the power plant of the Ohio State University, Columbus, Ohio. The boilers at both places were equipped with three-retort stokers.

The boiler trials at the laundry were carried on under the writer's direction in coöperation with Messrs. C. C. Brown, H. B. Craft and W. O. Durbin, members of the graduating class of 1913 in mechanical engineering at the Ohio State University, who incorporated the results of the trials in their graduating thesis.

The coals used were representative soft coals from the different fields lying in or adjacent to the Ohio fields and were as follows:

West Va. splint, nut, pea and slack, $2.40 per ton delivered.
Hocking, nut, pea and slack, $1.65 per ton delivered.
Pittsburgh No. 8 nut, pea, and slack, $2.20 per ton delivered.

THE BOILERS

The boiler is one of the Babcock & Wilcox cross-drum marine type, with vertical headers connected by 120 four-inch tubes (12 wide and 10 high) inclined from front to back and 17 feet 8 inches long. A steam drum 42 inches diameter and 9 feet 10 inches long is placed transversely over the rear header, to which it is connected by 12 4-inch circulating tubes, 3 feet 4 inches long. This drum is also connected to the front header by 12 four-inch horizontal tubes 15 feet 11 inches long, with the normal water level at the center of these tubes. The total heating surface is 2485 sq.ft., giving a builders' rating of 248.5 boiler horsepower. There are the usual three transverse passes for the flue gases through the boiler, the first baffle wall being a continuation of the back wall of the furnace and the second baffle extending down from above to the third row of tubes from the bottom.

The flue gases were passed to a Green fuel economizer having 160 four-inch tubes giving 2040 sq.ft. of heating surface. To provide ample draft facilities, the economizer is equipped with a 120-inch induced draft fan. The economizer is of unusually large size, its surface being over 82 per cent. of the boiler heating surface, to give a large storage capacity of hot water for laundry use.

At the university, the boiler tested is one of a battery of two, of the horizontal cross-drum, water-tube type known as the Flanner. It has 180 three-inch tubes 18 ft. long, 36 three-inch tubes 10 feet 8 inches long and 36 three-inch tubes 5 feet 3 inches long. These latter connect the front and rear headers to the steam drum, 54 inches diameter, 10 ft. long, which is placed transversely and nearly over the center of the rear half of the boiler. It has 3130 sq.ft. heating surface, with three transverse passes for the flue gases. This boiler is a part of the university boiler equipment, amounting in all to about 2000 rated boiler hp., all of which, with the exception of those recently installed and equipped with Taylor stokers, are operated wholly on natural draft.

METHOD OF CONDUCTING THE TESTS

During the boiler trials, excepting Nos. 8 and 9, the fireman followed the customary routine of operation, using his own judgment as to the proper thickness of fire, draft and time of dumping ashes. The tubes were blown about two hours previous to each test. At the laundry ten hours is the average length of time during which a steam supply is needed. Ten hours was therefore taken as the duration of trial, with readings every fifteen minutes excepting for the coal and water, which were weighed out as needed, and for the flue-gas analyses, which were taken every half-hour from a continuously drawn sample. All such readings were totaled or averaged for the entire run; the results are to be found on the observed data and result sheets (Tables 1 and 2).

These results, where necessary, are corrected for errors due to the instruments and the principal results as given are arranged in the order of the code recommended for boiler trials by the A. S. M. E. The furnace box pressure in inches of water was taken by a U tube manometer, the draft pressures by Ellison differential draft gages, the flue temperatures by 1000 degree F. Hohmann & Maurer mercury pyrometers, with 5 degree divisions, all other temperatures by the ordinary chemical thermometer with two degree divisions excepting the feed water thermometer, which was graduated to read degrees. The coal and water were weighed on platform scales of 1200 pound capacity capable of being read to within one half pound.

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*From a paper presented before the Ohio Society of Mechanical, Electrical and Steam Engineers, June 1914, at Sandusky, Ohio.

Coal samples were taken from each barrow or bucket of coal, amounting in all to about 500 pounds per trial. These samples were analyzed for moisture, ash and sulphur and the heating value was found by a Mahler calorimeter. In trial No. 7, the ultimate analysis was also found, but for the other cases the ultimates were figured from a known average ultimate analysis from the same vein of coal. The combustible in the ash was found from a sample of the refuse and ash in the ash pit. The percentage of unburned coal was found by the expression

$$d = \frac{a\,c}{(1 - a)(1 - c)}$$

Where d = Per cent of unburned coal in total coal as fired.
a = Per cent. of ash by analysis in total coal as fired.
c = Per cent. of combustible in refuse from ash pit.

TABLE 2 AVERAGE DATA AND RESULTS OF EVAPORATE TESTS

No. of trial	1	2	3	4	5	6	7	8	9	10
Coal per hr										
32 Fired per hr	1612	1576	1595	1943	1825	1747	1601	2076	2528	2476
33 Per sq ft grate	49.1	47.8	48.4	58.9	55.3	53.1	48.5	46.0	56.2	55.1
34 Combustible burned per hr	1338	1230	1168	1397	1441	1425	1265	....	1988	2050
35 R.p.hr. stoker crank shaft	36	32.8	36.3	41	38.4	37.8	38.5	41.7	51.8	....
36 Coal per retort per revolution....	15.0	16.1	14.8	15.8	15.9	15.9	15.8	16.6	17.3	....
37 Coal per hr. per boiler hp....................	3.78	3.72	4.31	4.73	4.19	4.21	4.06	3.96	4.34	....
Water per hr										
38 Fed to boiler, lb............................	13,723	13,657	12,054	13,280	13,966	13,255	11,255	11,309	....	....
39 Quality of steam	98.5	97.7	98.2	97.9	97.9	97.8	99.0	99.0	99.4	99.3
40 Equivalent dry steam, lb	13,516	13,334	11,834	12,995	13,668	12,964	11,279	....	16,865	....
41 Factor of evaporation	1.091	1.092	1.083	1.093	1.101	1.110	1.206	....	1.192	....
42 Equiv. evaporation from and at 212°, lb.......	14,741	14,590	12,808	14,204	15,049	14,390	13,603	....	20,105	21,877
43 Equiv. evap. per sq.ft. heating surface, lb......	5.90	5.84	5.12	5.68	6.02	5.76	4.33	....	6.38	....
43A Cost per 1000 lb. equiv. evaporation........	13.12c.	12.96c.	10.27c.	11.29c.	13.36c.	13.34c.	....	....	....	
Horsepower										
44 Developed	426	423	371	411	436	415	394	524	583	635
45 Builders rating	248.5	248.5	248.5	248.5	248.5	248.5	313	313	313	313
46 Per cent. builders rating....................	172	171	149	165	176	167	126	167	186	203
Economic Results										
47 Water fed per lb. actual coal, lb..............	8.52	8.67	7.56	6.84	7.66	7.50	7.13		6.71	7.55
48 Equiv. evaporation per lb. actual coal, lb......	9.15	9.26	8.03	7.31	8.25	8.24	8.49	8.71	7.96	8.95
49 Equivalent evaporation per lb combustible burned, lb...............................	11.02	11.86	10.97	10.17	10.45	10.09	10.75		10.11	10.68
Efficiency										
50 Boiler and furnace, per cent..................	71.8	77.3	74.7	69.4	69.3	66.7	71.0	.	66	68.1
51 Boiler, furnace and grate, per cent...........	69.9	72.5	69.9	67.1	66.3	63.5	67.6	65.8	59.0	
Flue gas per cent. by vol.										
52 Carbon dioxide..............................	15.20	14.20	13.50	14.70	12.40	12.10	10.84	12.95	11.97	14.60
53 Oxygen..	3.46	5.22	5.50	2.30	5.51	5.20	8.32	5.33	4.52	2.70
54 Carbon monoxide............................	0.39	0.40	0.09	0.70	0.05	0.15	0.13	0.40	0.91	0.25
55 Per cent. excess air	19.4	33.6	34.9	12.0	34.1	31.6	65.2	33.0	26.3	....
56 Air req. per lb. coal........................	8.9	8.6	8.2	7.6	8.3	9.0	8.5		8.5	....
Heat losses, per cent.										
57 Latent heat	3.54	3.53	4.17	4.43	3.85	3.61	3.66	3.33	3.10	3.84
58 Carbon monoxide	1.38	1.40	0.36	2.67	0.24	0.66	0.63	1.61	3.53	1.29
59 Products of combustion......................	12.71	11.95	11.69	12.69	11.99	11.42	7.77	6.92	6.91	11.19
60 Excess air	2.11	3.42	3.54	1.28	3.51	3.13	3.99	2.02	1.57	1.37
61 Radiation, etc.	7.19	1.25	5.65	8.39	9.75	12.93	12.17	12.48	15.82	11.41
62 Per cent. black smoke by chart.	12.1	17.0	5.0	15.7	12.7	13.8	....	....	....	15.0

The percentage of moisture in the steam was obtained by a Barrus throttling calorimeter attached to the steam pipe near the steam outlet to the boiler.

The efficiency of the boiler and furnace is taken to be the heat actually absorbed by the water evaporated by one pound of combustible burned, divided by the heating value of one pound of combustible.

The efficiency of the boiler, furnace, and grate is taken to be the heat absorbed by the water evaporated by one pound of coal as fired, divided by the heating value of one pound of actual coal.

DISCUSSION OF THE PRINCIPAL RESULTS

The results obtained from the trials at the laundry indicate on the whole a satisfactory performance for a boiler equipment of the smaller sized unit when operated under overload conditions with the ordinary care of the average fireman.

The side cleaning doors bring the ash bed within easy view, and the rocking and jarring action of the extension grate in most cases will be sufficient to break up the clinker preparatory to dumping. The extension grate when raised to its highest position not only prevents the coal bed from sliding forward when the dump plate is down, but makes it possible to feed the coal continuously during the dumping period, thus keeping up the steam pressure.

The ease with which the dumping process is managed will depend largely upon the clinkering properties of the coal. If the coal has an ash easily fusible under the action of the high furnace temperature and the increased air blast necessary for high overload operation, the clinker will prove troublesome by choking the grates and retarding the draft.

TABLE 3

Trial No.	Kind of Coal	Interval between Dumps, Hr.	Per Cent Unburned Coal	Per Cent Sulphur
1.....	W. Va. Splint	2.5	2.73	1.06
2.....	W. Va. Splint	2.5	5.94	1.58
			Av. 4.34	Av. 1.32
3.....	Hocking	2	5.34	1.08
4.....	Hocking	2	3.44	0.86
			Av. 4.39	Av. 0.97
5.....	Pitts. No. 8	3	4.30	3.64
6.....	Pitts. No. 8	3	4.70	3.56
			Av. 4.50	Av. 3.60
7.....	W. Va., Fairmont District	2.4	4.21	2.79
8.....	W. Va., Fairmont District	1	7.83	2.42
9.....	W. Va. (washed), from Thacker coal fields	1	10.17	3.36
10....	Thacker nut and pea	2.5	2.3	1.10

For dump periods ranging from two to three hourse (Table 3) the percentage of unburned coal passing into the ash pit averaged 4.36% for Trials 1 to 7.

For Trials 8 and 9 with one hour dump periods the average unburned coal loss was 9 per cent., showing that the unburned coal loss varied about inversely as the length of the dump interval.

While the presence of sulphur in the coal may not have, as some claim, any great effect on the clinker formation, it was found at the laundry that the third kind of coal used (Pitts. No. 8), containg 3.6 per cent. sulphur, gave the most trouble from clinkering and, in addition, when the refuse was dumped or when the fan was slowed down temporarily, the sulphur fumes became almost unbearable.

UNBURNED COAL—The amount of unburned coal (Table 3) present in the ashpit refuse is influenced by the rate of coal feed, the number of dumps made and the degree to which the coal clinkers. If the coal is fed too fast, some of the coke may be pushed forward onto the dump plate where the air supply may be insufficient to burn it completely. When the refuse is allowed to accumulate too long, some of the coke may also become buried under the ash and clinker. The clinker, if easily fused, may run down and envelop some of the unconsumed coal. For the Pitts. No. 8 coal, with a three-hour dump interval, more trouble was experienced with clinker formation and a larger percentage of unburned coal was present in the refuse.

UNIFORM COAL FEED—The coal feed is uniform and positive and under control through the speed regulator on the fan engine. The rate of feed can be approximately determined by noting the revolutions of the upper rams, since each ram plunger forms a displacement meter and for the same kind and grade of coal will discharge nearly the same weight of coal per revolution of plunger. For the grade used in Trials 1 to 7 inclusive, the amount fed per retort per revolution of the stoker shaft ranged from 14.8 pounds to 16.1 pounds, with an average of 15.7 pounds.

For the different kinds of coal used the average rates of combustion are given in Table 4.

TABLE 4

Trial No.	Kind of Coal	Lb. per Retort per Revolution	Rev. of Stoker per Hr.	Coal per Hr. per Sq.Ft. Grate	Coal per Hr. per Boiler Hp.
1.....	West Va. splint	15.0	36.0	39.3	3.78
2.....	West Va. splint	16.1	32.8	38.4	3.72
3.....	Hocking	14.8	36.3	39.0	4.31
4.....	Hocking	15.8	41.0	47.5	4.73
5.....	Pitts. No. 8	15.9	38.4	44.5	4.19
6.....	Pitts. No. 8	15.9	36.8	42.8	4.21
7.....	West Va., Fairmont Region	15.8	38.5	35.6	4.06
8.....	West Va., Fairmont Region	16.6	41.7	46.0	3.96
9.....	West Va. (washed), Thacker coal fields	17.3	51.8	56.2	4.36
10....	Thacker nut and pea	15.3	53.9	55.1	3.90

AIR REGULATION AND AIR EXCESS—Close air regulation is also possible and the proper amount is supplied entirely by means of the forced draft fan. For a given coal it is necessary only to determine the required amount of draft over the fire to secure good combustion conditions as shown by the flue-gas analysis. This is chiefly a matter of obtaining the right speed ratio between the fan engine and the stoker shaft. When the proper air supply is secured, it can be so maintained independent to some extent of the rate of combustion since the coal feed and air supply are both controlled by the fan-engine governor. Occasionally, the fireman may find it necessary in maintaining a uniform draft over the fire to adjust the damper in the air pipe leading to the windbox; but most of the regulation may be made at the flue damper. The tuyere box pressure should remain nearly constant for a given rate of combustion and draft over the fire; increasing with a higher rate of coal feed. Should it be necessary to increase the tuyere box pressure to get the proper draft over the fire, other conditions remaining constant, it would indicate that the fire bed was becoming clogged and that the air supply was restricted by clinker formation.

Where a CO_2 recording apparatus is available, the condition of the fire may be more closely watched and the air supply may be kept down to the point where carbon monoxide begins to appear.

During the tests at the laundry, owing to the extremely variable load, the draft over the fire showed a wide instantaneous variation ranging from a pressure slightly above zero to as much as ½ inch suction, though the average results are fairly uniform, varying from 0.09 inch to 0.19 inch. This could be improved by placing the induced draft fan at the economizer and the stoker fan under the same speed control which would tend to a more evenly balanced draft.

At the university the fireman was aided in the management of the stoker by a General Electric steam flow meter near by, which indicated the output of the boiler, and also by a gage showing the amount of draft carried over the fire. For trial No. 7 this gage varied from zero to 0.15 inch suction with an average of 0.045 inch.

This close air regulation, together with the fact that the air in passing through the tuyeres is preheated, and also because of the fairly large combustion chamber, will result in a high furnace temperature; consequently a more complete state of combustion is secured with good smokeless conditions.

The smoke observations as given on Table 5 were taken with a Ringelmann smoke chart at the heaviest load period during each day's run at the laundry and show about the same degree of density for each day. The smoke was light in color and in general was only slightly darker with the increase in load. The percentage of black smoke by the chart ranged from 5 to 17 per cent. The flue-gas analyses showed that these nearly smokeless conditions had been accompanied by small percentage only of excess air, which dropped as low as 12 and never exceeded 35 per cent.

It will also be seen from Table 5 that for Trials 1 to 6 the amount of CO_2 ranges from 12 to 15 per cent., with a corresponding drop in the percentage of oxygen of from 5.5 to 2.5 per cent. and a CO content varying inversely as the oxygen.

Table 6 gives a few individual flue-gas readings as taken during the trials. These show that for CO_2 values up to about 12 per cent., only a slight trace of CO is present, while for values from about 12 to 16 per cent. large increases in CO may be expected up to 1.5 and higher. Hence, for running conditions as found at the laundry, it would seem unwise to raise the CO_2 much in excess of 12 to 13 per cent.

TABLE 5

Trial No	Flue Gas			Per Cent Air Exc	Flue Temp	Per Cent Loss Due to			Per Cent Black Smoke
	CO_2	O	CO			Prod. of Combustion	Exc Air	CO	
1	15.20	3.46	0.39	19.4	745	12.71	2.11	1.40	13.1
2	14.20	5.22	0.40	33.6	705	11.95	3.42	1.49	17.1
3	13.50	5.50	0.09	31.9	664	11.65	3.54	0.30	5.0
4	14.70	2.30	0.70	12.0	711	12.69	1.28	3.54	15.0
5	12.40	5.51	0.05	34.1	710	11.99	3.51	0.21	12.7
6	12.10	5.20	0.15	31.6	657	11.42	3.13	0.66	13.8
7	10.81	8.32	0.13	65.2	450	7.77	3.99	0.63	
8	12.95	5.33	0.40	33.0	466	6.92	2.02	1.61	
9	11.97	4.52	0.91	26.3	485	6.91	1.57	3.53	
10	11.60	2.70	0.25	14.3	687	11.19	1.37	1.29	15.0

TABLE 6

Flue Gas Per Cent. by Volume

CO_2	O	CO
10.0	9.0	0
12.4	6.4	0.1
13.0	5.8	0.2
15.0	3.1	0.5
16.0	1.0	1.50

For Trial 7 the CO_2 ranged from 9 to 13 per cent. with an average of 10.84 with CO ranging from 0 to 1 per cent. averaging 0.13. The flue-gas conditions, as might be expected, ran a little better during the first half than during the latter half of the trial, due in part to change in firemen, the one for the last half tending to carry a thinner fire.

Trial 8 gives good CO_2 results with 33 per cent. excess air, but shows an increase in CO, rising to about 0.4 per cent.

Trial 9 is given to bring out a state of combustion which may prevail where a comparatively low value for CO_2 is obtained (12.95 per cent.) even with a low percentage of oxygen (4.52) giving a low percentage of excess air (26.3 per cent). The high percentage (0.91 per cent) of CO obtained shows an unequal air distribution, due probably either to the clogging of the air passages caused by the high caking tendencies of the coal or by the liberation of gusts of volatile gases which failed to be fully burned in the combustion chamber before reaching the cooler surfaces of the boiler tubes. The last kind of coal (Pitts. No. 8) used at the laundry and the coal used at the university, especially that for trial 9, had higher caking properties than either the West Virginia Splint or the Hocking coal, which would seem to indicate that a caking coal was harder to manage in this class of stoker than a noncaking or free-burning coal.

TABLE 7. OVERLOAD CAPACITY AND EFFICIENCY

Trial No.	Per Cent. Rating	Equiv. Evap. per Lb. Actual Coal Lb.	Equiv. Evap. per Lb. Comb. Burned Lb.	Efficiency Boiler, Grate and Furnace Per Cent.	Coal per Hr. per B.hp. Lb.	B.t.u. Actual Coal	Radiation, Etc.
7....	126	8.49	10.75	67.6	4.06	12,184	12.78
3....	149	8.03	10.97	69.9	4.31	11,164	5.65
4....	165	7.31	10.17	67.1	4.73	10,570	8.39
6....	167	8.24	10.09	63.5	4.21	12,582	12.93
2....	171	9.26	11.86	72.5	3.72	12,375	1.25
1....	172	9.15	11.02	69.9	3.78	12,697	7.19
5....	176	8.25	10.17	66.3	4.19	12,067	9.75
8....	167	8.71	.....	65.8	3.96	12,830	12.48
9....	186	7.96	10.11	59.0	4.34	13,120	15.82
10...	203	8.95	10.68	68.1		12,744	11.41
					Av. 4.15		

Table 7 contains the average results for the combined boiler, furnace and grate efficiencies at overload capacities for the nine trials. The percentage of rating for Trials 1 to 7 varies from 126 to 176 per cent., with more than half the trials averaging about 165. At the laundry the combined efficiencies, with one exception, range from 66.3 to 72.5 per cent. The trials showing the lowest efficiencies were those where Pitts. No. 8 coal was used, which gave the most trouble from clinkering and which also seemed to be a higher caking coal than the other two kinds used. The extreme fluctuations in the load at the laundry made it difficult to regulate the thickness of the fire, and this fact emphasizes the need of maintaining a boiler test for at least ten hours unless the load should remain fairly uniform.

Trial 7 shows a lower efficiency (67.6) at the small over rating than was to be expected from the trials preceding. The percentage of unburned coal remained about the same, but a greater excess air was carried and a higher probable loss because of radiation is to be seen, due to greater exposed radiating surface.

Trials 8 and 9 were maintained for percentage ratings of 167 and 186 respectively, but the combined efficiencies obtained were low and the highest contributing factor to these low results appears to be the high unburned coal loss (10.17 per cent.) resulting from the too frequent dumping of refuse. The CO loss is also high in Trial 9, showing restricted and unevenly distributed air supply, notwithstanding the high furnace box pressure (.276 inches) maintained. Probably 6 per cent. at least might have been saved from these two sources alone.

The radiation losses from the trials at the laundry are somewhat variable, ranging from 1.25 to 12.8 per cent. Throwing aside the lowest result, which seems to be in error, the average radiation loss is 8.8 per cent. as compared with 12.6 per cent. for trials 7 and 8.

The coal fired per hour per boiler horsepower (Table 7) runs from 3.52 to 4.73 pounds, averaging 4.15 pounds for the nine trials.

As might be expected, these results do not give the high efficiencies looked for from a boiler trial where the load is carefully regulated, where the flue-gas conditions are carefully watched and the combustion is so adjusted as to reduce the furnace losses to a minimum.

At the Detroit-Edison tests of 1911,* Dr. Jacobus was able to get, on a Stirling boiler of 2365 hp. rating equipped with a 26-retort Taylor stoker, efficiencies of 80 per cent. for 100 per cent. rating and 76 per cent. for 200 per cent. rating, for 24-hour trials, using 14,000-B.t.u. coal. The loss due to unburned coal running about 3 per cent. as compared with 4.4 per cent., the average unburned coal for Trials 1 to 7 inclusive, the radiation loss, necessarily much less than for the small units, averaged 2.81 per cent. as compared with 8.8 per cent. and 12.6 per cent. for the three-retort unit. On the large unit, the coal burned per hour per boiler horsepower averaged 3.11 lb. (14,000 B.t.u.) as compared with 4.15 (12,000 B.t.u.), or 3.56 pounds (14,000 B.t.u.) per hr. per boiler horsepower for Trials 1 to 9 inclusive.

A report on eleven other trials† made in 1913 for the National Tube Co., Kewanee, Ill., on a 600-hp., four-pass Edge Moor boiler, with a seven-retort Taylor stoker, gave combined efficiencies ranging from 80 per cent. at boiler rating to 69 per cent. for 200 per cent. rating. These trials were carried on for periods of eight hours, and because of the careful supervision and management during the trials, the efficiencies agreed closely with those of a 72-hour check run made later.

At the university some years ago, a combined efficiency of 71.5 was obtained on a 100-hp. Babcock & Wilcox boiler with a stationary top feed, hand-fired grate using Pocahontas coal. This test, however, and also the others just mentioned, were conducted with the greatest possible care, and the precautions thus taken would account for the excellent results obtained.

The tests discussed in this paper, made as nearly as possible under average daily operating conditions, would seem to indicate that a fairly high overall efficiency for this type of stoker is within reach of the average fireman. His interest will be greatly aroused and his efficiency will be proportionately increased by the use of some of the boiler-room indicating appliances such as the indicating flow meter and the flue gas and draft recorders.

In conclusion, it may be said that the chief controlling factors influencing the efficiency of a Taylor stoker at overload capacity appear to be:

1. Size of the unit.
2. Percentage of overload.
3. Character of coal.
4. The use of indicating boiler room appliances.
5. The intelligence of the fireman.

The factor of most importance is, without doubt, the degree of intelligence which the fireman possesses and the interest he takes in improving the operating conditions.

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*Trans. A. S. M. E., Vol. 33, p. 582.

†Power, Feb. 24, page 285.

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Steam-Boiler Construction and Inspection*

By H. A. BAUMHART

A boiler must be so designed that the shell or drum, including the covering strips at the longitudinal joint, can be formed to a true circle to avoid bending under pressure. This would exclude the lap-seam form of construction. The lap-seam form of joint should be eliminated, excepting in shells of small diameter and comparatively low pressures. Flat surfaces requiring staying or bracing are a source of considerable anxiety to a boiler inspector. Solid stay-bolts are commonly used. The factor of safety recommended for such bolts varies from 7 to 8, according to the quality of material used. If stay-bolts were subjected to a tensile stress only, failure would rarely occur. There is, however, another condition of service in connection with stay-bolts to be recognized, that is, unequal expansion and contraction. When the fires are lighted the inner box plate or tube sheet becomes heated first, and expands in advance of the outer plate. Later, as steam is generated, the outer plate expands up to or beyond the inner plate, thus making two bends of the bolts at each operation. It is true that the bend is only slight, but it is of sufficient frequency to break the bolt, and, in some cases where the fireboxes are of considerable length, within a month's time. The outer plate is usually thicker than the inner and holds the bolt more firmly, causing it to bend and ultimately to break where joined to the outer plate.

There is another serious problem in connection with stay-bolted surfaces. The stress due to unequal expansion and contraction causes movement of the bolt in the hole of the outer sheet, producing corrosion or flaking off of the material at the inner end of the stay-bolt hole until frequently the riveted end of the bolt is the only portion holding. In lighter material this stress sometimes produces slight bending of the plate with such frequency that it produces cracks extending in every direction from the stay-bolt holes. These cracks are visible only from the inside, and because of the limited space they cannot be seen without first removing some of the bolts, and, therefore, may not be detected until leakage appears. The best remedy for such a condition is a flexible bolt. The hollow bolt is an improvement only because leakage will appear when the bolt is broken, and, therefore, is recommended by some inspectors in preference to the solid bolt.

The heads for drums or domes should be of the convex, or what is commonly known as bumped, type. Care should be exercised in forming the head in order to obtain a true curvature and to avoid the possibility of the head bending under pressure. Such a head having a manhole should be made of material not less than ⅛ in. heavier than the blank head in order to give it sufficient stiffness to avoid bending, because of the manhole opening. For extremely high pressures, such as carried on air-storage tanks operating under 1000 lb. per square inch, the heads should be made cone shape. This shape is stronger than the bumped head, but more expensive to construct, and is seldom used excepting for extremely high pressures.

The question of bracing flat heads is also an important one and care should be had to see that the braces are so distributed that each will carry its share of the load. It is also important to attach the braces to the heads or shell plate to avoid double thickness of material on the heating surface.

Until about 1880, iron was used exclusively for boiler plate. A very high grade of iron plate was manufactured, having a tensile strength varying from 42,000 to 45,000 lb.; in a few cases 50,000 lb. was obtained. It was not readily susceptible to attack by acids and, therefore, its deterioration, even in locations where the water was contaminated, was comparatively slow as compared to modern steel. Steel boiler plate replaced iron several years ago. Great care is necessary in the preparation of steel for boiler plate.

Other ingredients besides carbon are sulphur and phosphorus, but only traces of these two can be permitted in the best quality of boiler steel. The more injurious of these is phosphorus. Boiler steel must be made by the openhearth process. The percentage of phosphorus should not exceed 0.03 per cent. and sulphur should not exceed 0.04 per cent. for the best grade of steel. A maximum tensile strength of 60,000 lb. per sq.in. is usual, and 54,000 lb. is preferable. A certified copy of the mill test report should accompany each plate entering into the construction of a boiler.

The use of cast iron for any of the pressure parts of a steam boiler is not recommended. Cast steel or forged steel should be used wherever possible.

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*From a paper presented before the Ohio Society of Mechanical, Electrical and Steam Engineers, June, 1914.

The best material may be so handled by an incompetent workman as to render it unfit for service. This is especially true in connection with forming the shell plate and butt straps. If the shell plate and straps are not formed to the proper circle, either by a rolling or a pressing process, and the boiler maker attempts to make the proper fit with the aid of a sledge hammer, fractured plates will probably result. Such cracks may be so slight at first as to defy detection even by the aid of a glass, but they will extend in dangerous proportions after the boiler is in service.

No rivet hole or tube hole should be punched; they should be drilled. State and municipal laws permit the holes to be punched small and reamed to size, which is only a compromise arrangement. My advice when ordering a boiler would be to insist upon having every hole drilled from the solid. While it is true that reaming does remove a considerable portion of disturbed molecules, it does not remove all of them.

The caulking edge of the plate and butt straps should be prepared on a planer. Bevel shearing should not be permitted because it produces the same bad result as punching a hole in the plate; that is, it disturbs the material for a considerable distance from the edge, producing numerous minute cracks, always an element of danger.

There is a vast difference of opinion among mechanical engineers and boiler manufacturers with reference to the proper factor of safety. Modern rules adopted by the various states and by the provinces of Canada require a minimum factor of safety of 5, the United States marine rules not less than 4. In my judgment a factor of safety of 5 should be the minimum. To illustrate this point more clearly, I would refer to a record relating to a test of material and which is a part of the records of the American Society of Mechanical Engineers. At a factor of safety of 2, the number of repetitions of stress required to produce rupture was 20,000; at a factor of safety of 2.5, 210,000; at 3, 700,000, and at 3.5, more than 1,600,000. It would therefore follow that boilers operated under a factor of safety of less than 4, because of the so called fatigue of metal under stress, should not be used. A boiler operating under 4 or less could be expected to fail many years before another boiler operating under 5 or greater.

The subject of a proper retiring age for boilers comes frequently to light and is a most fruitful source of controversy. Of course, there can be no question as to the propriety of condemning those boilers whose diseases are no longer curable, but there is at once the basis for a deal of argument when an inspector approaches the owner of a boiler with the statement that it must be replaced because of old age, especially if it is known to have all the apparent qualifications, except youth, for many additional years of service. In the past many curious properties have been attributed to old boilers; one of the most interesting was the notion that they could not explode violently. It was supposed that an old boiler would merely rupture, allowing the pressure to be relieved much as if the safety valve had opened. This idea was definitely disapproved many years ago along with many other fallacies and much popular mystery concerning boiler explosions.

We all know that the steel used in boiler construction will deteriorate with use; it undergoes a slow loss in strength and ductility. The process is hastened by the presence of a moderate excess of phosphorus. Deterioration of this character cannot be determined by the usual method of inspection. It is, therefore, difficult to state definitely at what time in service the boiler should be abandoned. This places a great responsibility upon the inspector. He must consider, in addition to the general appearance of the boiler, the conditions under which it has operated, and he must also make allowance for defects in the material which are not visible. Experience shows that boiler plate, subjected to the high temperature of the furnace, does deteriorate to the extent that after about twenty or twenty-five years' service, the boiler should (if we follow the motto "Safety first") be taken out of service. Because an inspector reports that he considers the boiler unsafe for further use, it does not imply that he can predict the day and the hour when it will explode; it does mean, however, that the factor of safety is too low, and to continue the boiler in service for any considerable length of time presents a hazard too dangerous to be undertaken.

A steam boiler explodes or fails from one cause only, and that is, the boiler or the part which fails could no longer resist the strain placed upon it. The applied pressure may be sufficient to rupture a sound boiler, or the boiler may have reached such a state of deterioration that the ordinary working pressure becomes an over-pressure. In the majority of serious explosions, the primary cause was due to the lap-seam form of construction.

Many accidents are due to overheating of the shell plate or tubes. The overheating may result from various causes. The common cause is a deposit of scale, sediment, oil, or a combination of oil and scale on the internal surfaces. The presence of oil or grease, although in moderate amounts on the internal surface of a shell plate or tube is dangerous, and, unless removed promptly, will result in a damaged or possibly an exploded boiler. Great care should be exercised to prevent oil entering a boiler.

By referring to the records of the Hartford Steam Boiler Inspection & Insurance Co., I find the following for the United States:

Year	Boiler Explosions	Persons		
		Killed	Injured	Total
1911	499	222	416	638
1912	537	278	392	670
1913	499	180	369	549

The annual property damage is estimated at a half million dollars. The above records include boiler accidents of every description, some of which were of minor importance. We are much encouraged because of the great interest now taken by engineers everywhere insisting upon proper construction and inspection of steam boilers. In many locations boiler inspection is required by law. The situation, therefore, as regards safety is gradually improving. We have not yet reached the stage of no boiler accidents; such a condition will never exist. There will be boiler explosions as long as steam boilers are used. We have not yet reached the stage of perfection in the manufacture of material, neither have we reached perfection in the art of boiler design. We learn as much from the result of failure as from the result of success. Further experiences in the operation of steam boilers may teach us that some radical change in design or character of the material is required to make boilers that will not explode under constantly increasing pressure and temperature.

Another condition which must be considered in connection with the safe operation of steam boilers is their care and management. It frequently happens that a boiler explosion, or some other calamity resulting in loss of life, occurs where it is least expected. This proves that, in spite of the advanced precautions that science has provided, reliance must still be placed in human intelligence and faithfulness to a large degree and that sometimes these fail.

It is recommended that boiler owners and users provide every possible method of safeguarding human life and property by purchasing only such boilers as have been thoroughly inspected during construction and by seeing that they are also inspected during the life of the boilers. Fortunately, in the state of Ohio such conditions now prevail. It also devolves upon the owner or user of a boiler to select only such persons as are fitted to care for them.

Ohio Society Spring Meeting

The spring meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers was held at Sandusky, Ohio, June 11, 12 and 13. On Thursday evening the papers upon "The Taylor Stoker Operating under Average Conditions," by Horace Judd, and "Steam Boiler Construction," by H. A. Baumhart, to be found on pages 897 and 900, were presented and discussed. On Friday evening a paper was to be presented on the "Uniflow Steam Engine," by James H. Debes, chief engineer of the C. & G. Cooper Co. In Mr. Debes' unavoidable absence, A. C. Ruhl, who is in charge of a plant at Port Clinton in which there is one of the Cooper uniflow engines, told of his experience with it. There had been some difficulties, but the engine was now running satisfactorily and with the straightening out of the condenser and cooling water conditions, will undoubtedly run with remarkable efficiency. They had, upon a recent test, obtained a performance of 11¾ lb. of steam per indicated horsepower with a 24-in. vacuum, 170 lb. pressure and 30 deg. of superheat. The engine is 34 in. diameter, 36-in. stroke, and runs at 125 revolutions.

Embury A. Hitchcock, power sales engineer of the E. W. Clark & Co. Management Corporation, gave an interesting lecture on the "Power Plants of the South," illustrated by lantern slides. A. C. Rogers, superintendent of heating of the Toledo Ry. & Light Co., questioned a statement made by F. W. Ballard, chief engineer of the municipal electric-light plants at Cleveland, at a previous meeting, that they were making 1000 lb. of steam for 10c. This would hardly pay the coal cost, and he objected to such statements going out with the apparent sanction of the society. A discussion of the statement is promised for the next meeting.

Visits were made to the plants of the Libbey Glass Co., the Sandusky Gas & Electric Co., the Lower Lakes Docks Co., the quarries of the Breakwater Construction Co., at Johnson Island, the new filtration plant, and the pleasure resort at Cedar Point.

Master Steam and Hot-Water Fitters Convention

The twenty-sixth annual convention of the National Association of Master Steam and Hot-Water Fitters was held at Atlantic City, June 10 to 13, inclusive, with headquarters at the St. Charles Hotel.

Wednesday was taken up by the meetings of the board of directors, the committee on standardization and committee on trade relation. The first general session of the convention was called to order at 10:30 o'clock Thursday morning by President Edward B. Denny. Mayor Riddle opened a "canned speech of welcome," and got the one intended for the plumbers' convention. He qualified the error by stating that the prices of the steam fitter and the plumber were so nearly alike in high-rate charges that his little mistake would make no difference.

Delegates and Guests of the National Association of Master Steam and Hot-Water Fitters, in Convention at Atlantic City, N. J.

President Denny, in his annual address, extended a welcome to the members of the convention, to the ladies, the manufacturers and their representatives, and the members of the trade press.

In speaking of the work of standardization President Denny said that in connection with the schedule of flanged fittings and flanges that at one time it seemed that the years of effort to establish a uniform schedule might be entirely nullified by an opposing combination. This was prevented by the committee in arranging for a conference in Washington, D. C., of all parties interested, at which conference a basis of agreement was reached eventually resulting in the final adoption of the uniform schedule known as the 1915 U. S. Standard Schedule, leaving the name in controversy, however, some of the committee of the American Society of Mechanical Engineers desiring to call it the "American Standard" schedule. The standardization committee is still at work on the problem of radiator valves, boiler ratings, lock-shield air valves, uniform height of radiator outlets and other items of importance to the master steam fitters.

The president referred to subcontracting and of the conference committee's efforts to subdue and destroy the evil, and to the success in securing separation of mechanical equipment from general contracts in state, county and municipal buildings in several states. He stated that bills providing for such separation are pending in the legislatures in other states.

According to President Denny, there is more or less complaint about the sale of material by the manufacturers and dealers direct to the consumer, and about the losses and annoyances arising from subcontracting, but the one great evil is the low competitive bidding, which eliminates all profits on contract work. A large proportion of the contract work done by the master steam and hot-water fitters is at prices which do not repay overhead charges, which condition in many cities has caused the more competent and responsible master steamfitters to abandon the business, and many others would gladly do so if they could retire without debt.

The speaker was not hopeful of business conditions, the most apparent cause for depression to pipe fitters being the practice of manufacturers and dealers of supplying brains and capital for men who have had no business training ano starting them in their career as destructive master steamfitters, hundreds of men whose only qualification is their ability to cut, thread and screw pipe. It was hoped that the financial losses which are sure to follow will finally result in its discontinuance. If jealousies and animosities give way to friendliness and helpfulness, fair and equitable prices would be placed upon all work, whether contracting or jobbing, and the manufacturers and dealers would recognize the master steamfitters as necessary middlemen, entitled to a profit on the goods handled, and would cease to swamp the business with incompetent and irresponsible master steam fitters. The remainder of the session was taken up with the reports and appointment of committees.

The afternoon session convened at 2:30 o'clock and was devoted to committee reports. The report of the conference committee regarding the evils of subcontracting had, among other things, the following statements which were used in the two interviews with the committee appointed by the American Institute of Architects, with the result that they passed a resolution condemning the practice. In the May 20, 1912, meeting the following was presented:

> It costs the trade, as a whole, more to estimate for general contractors than is realized from the profits made on all the work obtained from them. The actual cost to each steamfitter or plumber will average not less than ½ per cent. on the amount of an estimate. It costs each not less than $10 to figure the cost and to prepare and submit an estimate for a $2000 contract. When such estimates are made direct to the owner, the average number of bidders will be five, in

which case the cost to the trade will be $50 for estimating; but if the same work is included in a general contract, there will be an average of five general contractors bidding on it, each of whom will get from five to ten estimates from plumbers and steamfitters. If the average number of such sub-estimates is but twenty-five, the cost to the trade will be $250.

The average profit on a $2000 contract does not exceed $200. It will be seen from these conservative figures that while the profit on such a contract made direct with the owner may amount to $190, the profit to the trade as a whole is but $150 after deducting the cost of estimating, but the same contract taken through a general contractor actually costs the trade $50 more for estimating than the successful subcontractor can make on it.

Estimates given to general contractors are not, as a rule, fairly handled. No provision is, or can be, made for the estimates being opened in the presence of bidders and the awarding of the contract in accordance with fair competitive rules. Usually they are opened as received, by the general contractor or one of his employees, and the figures may easily be obtained by favored competitors. If the general contractor gets the work it is seldom that he awards the subcontract on the merits of the sub-bids he has received; either a favored party is offered the contract at the price of the lowest bidder or else new bids are obtained, often from new bidders, and not infrequently the lowest final bidder is induced to take the contract at a lower price by false representations as to the estimates of his competitors.

Many general contractors are unable to properly finance the work they undertake and depend largely upon their credit to carry it through. In this "credit" they include the subcontractor. Almost invariably the steamfitter's payments are delayed long after the general contractor has received them.

In many places the lawful provision made to safeguard the claims of building contractors is nullified and lost to the subcontractor who, in the event of failure of the general contractor cannot recover from the owner because there is no agreement between them.

The nature of the work is such as to justify and often necessitate direct contact with the owner, or his representative, the architect. The general contractor is not concerned in such changes and betterments as are often made clear to the practical artisan as the work proceeds and frequently an inferior installation is made because of the indifference of the general contractor who cares only to comply with the specification.

It is reasonable to conclude that the same work done through a general contractor will cost the owner more than if done directly for the owner. In some way the general contractor will get a profit. If it is made to seem that the building costs less by general contract, the owner may be sure that he is getting less in quality or quantity. No steamfitter or plumber will do the same work cheaper for the general contractor (with all the risk and disadvantages) than he would for the owner.

While the evils of subcontracting are generally recognized among the master plumbers and master steamfitters, and resolutions have been adopted by both national associations reprobating the practice, there is no power to compel the members to cut out such business. Many, however, refuse to figure for general contractors and among those who thus refuse are many of the most reliable concerns in both lines of business.

At the meeting held Nov. 12, 1913, the conference committee submitted additional arguments in part as follows:

"The interest in the matter of divorcing what may be considered 'the mechanical equipment of buildings' from the bid of the general contractor is national in its scope. The one feature which has occupied the center of the stage has been 'the abuses practiced by the general contract.' That these abuses, many in number and variety, exist, is generally conceded by everyone with the possible exception of the general contractor.

"There are other features, however, which must not be allowed to be totally eclipsed by this seemingly major feature. There are four principal parties to one of these contracts, as follows: The owner, the architect, the general contractor and the subcontractor.

"As a general principle, it will be admitted by all fair-minded persons that the rights of each of these parties should be recognized and should be secured.

"The rights of the owner and of the architect are usually clearly defined and secured in the terms of the contract.

"The rights and duties of the general contractor are clearly defined in this same instrument, but when it comes to the rights and duties of the subcontractor no reference is made, it being left to the general contractor to select his subcontractors and make with them the best possible 'dicker.'

"In the selection of his architect, the owner is usually influenced by the character of the man and that of the work that man has actually produced. Having made his selection the owner should be warranted in feeling that his interests are safe because he has placed his work in the hands of architects noted for these qualities. The plans and specifications are ready and the architect calls in the 'general contractors,' and for one reason or another he is often obliged to receive proposals from general contractors of whom, in some cases, he knows little and in other cases in whom he has little confidence. Is it fair to allow such a general contractor to select his subcontractor?

"In nearly every instance where this has been discussed architects have admitted the advisability and feasibility of adopting our suggestions with one exception. They claim that it is most important that building operations should be finished 'on time' and they seem to be a unit in the thought that this can be accomplished only by having the work done under one general contract.

"Responsibility should be placed where it belongs, not by the general contractor but by the architect; every party to the contract should be held to strict accountability for the performance of his part of the work. No man should be blamed for omissions or commissions which strictly do not belong to him, and the judge of all this should be the architect; the owner expects and is entitled to this from him.

"There may be other ways of correcting this evil, but just now only two ways occur to us. The first and better way is for the architects to adopt measures to that end.

"The second is for the subcontractors to stand together and absolutely refuse to submit estimates to general contractors."

In the evening the members and guests enjoyed a lecture, illustrated by motion pictures, on the manufacture of modern welded pipe from ore to the finished product, by Frank N. Speller, of the National Tube Co.

Friday's session was devoted to a report of the convention committee and a discussion of topics brought before it. The election of officers during the afternoon session resulted as follows:

President, John T. Bradley, St. Louis, Mo.; first vice-president, Juan A. Almirall, New York City; second vice-president, Frank G. Carthey, Salt Lake City, Utah; third vice-president, Edmund Grassler, Milwaukee, Wis.; Board of Directors, John F. Bradley, Missouri; Juan A. Almirall, New York; Edmund Grassler, Wisconsin; John E. Rutger, New York; Edward B. Denny, New Jersey: William H. Oakes, Massachusetts; N. Loring Danforth, New York, and Noble P. Bishop, Connecticut. Sargeant-at-arms, John C. F. Trachsel, Pennsylvania. These newly elected officers were then installed. Retiring President Bradley was presented by the members of the association with a desk inkstand of artistic design.

The last session was held on Saturday morning to dispose of unfinished business and for a discussion of such topics as might come before the convention.

New York State N. A. S. E. Convention

The nineteenth annual convention of the New York State Association of the N. A. S. E. was held in Rochester on June 11, 12 and 13. The Seneca Hotel was the headquarters. There were about fifty delegates in attendance. The several sessions of the delegates were held in the auditorium of the Armory Building, and in the main hall adjoining was the mechanical exhibit of the supplymen, where the newest devices, apparatus and sundries of all kinds were displayed. The hall was tastefully decorated and conveniently arranged.

At ten o'clock on Friday morning the convention was called to order by A. J. Ranton, chairman of the convention committee, who introduced the speakers. Mayor Edgerton welcomed the company to the city, and State President E. E. Pruyn responded. Interesting addresses were also made by City Engineer Fisher; James R. Coe, national president of the N. A. S. E.; R. M. Searle, and William J. Reynolds, past national president of the N. A. S. E.

On Friday afternoon the delegates and guests visited the plant of the Taylor Instrument Co., while the ladies took chartered cars for an afternoon of pleasure at Ontario Beach. In the evening at eight o'clock there was a theater party at the Lyceum.

The feature of the entertainment furnished was the performance given in the convention hall on Saturday evening. The Rochester City Orchestra supplied the music, and an enjoyable program was made up by the following gentlemen: Herbert Self, Peerless Rubber Manufacturing Co.; "Lagonda" Mustin, the Pittsburgh representative of that company; Billy Murray, Jenkins Bros., and Jack Armour, of "Power." During the evening Past National President William J. Reynolds presented to retiring State President E. E. Pruyn a handsome French clock, the gift of the delegates and supplymen. Mr. Pruyn made a feeling address of appreciation.

Following are the state officers elected for the ensuing year: Fred Felderman, New York City, president; William H. Aydelotte, vice-president, Niagara Falls; William Roberts, secretary, Yonkers; William Downes, treasurer, New York City; William H. Dolamo, conductor, Rochester; Edward G. Geib, doorkeeper, Buffalo; William Downey, chaplain, Brooklyn.

The exhibition was liberally attended and the following firm were represented

EXHIBITORS

John A. Roebling's Sons Co.
Lagonda Manufacturing Co
Albany Lubricating Co
M T. Davidson Co
Jenkins Bros.
United States Rubber Co
M E. Wolff Co
Geo. Van Vechten Co
Genesee Boiler Works
Rochester Vacuum Valve Co.
Jacob Hauser
Peerless Rubber Manufacturing Co.
N B. Fails Lubricating Co
Garlock Packing Co.
Lunkenheimer Co.
Howe & Bassett Co.
Otis Elevator Co.
William Wilson
Greene Tweed & Co.
Cling-Surface Co.
Strong-Hery Co.
Haverstick & Co
Barr & Creelman
Boig & Hill
Luitweiler Pumping Engine Co.
The V. D. Anderson Co.
L. Ernst Sons
"Power"
B. Fanning
Rochester Railway & Light Co.
Barrett Manufacturing Co
Ashton Valve Co.
United States Graphite Co.
Mark Union Co.
McLeod & Henry Co.
Griscom-Russell Co.
Crandall Packing Co.
Armstrong Cork & Insulation Co.
Rowe & Waddell
Dearborn Chemical Co.
H. W. Johns-Manville Co.
Keystone Lubricating Co.
Syracuse Faucet & Valve Co.
Cross Bros.
A. L. Covill
Wheeler-Green Co.
Rochester Electrical Contracting Co.
Taylor Instrument Companies
Weaver Hardware Co.
City of Rochester
Wm. Powell Co.
Quaker City Rubber Co.

PATRONS

Diamond Power Specialty Co.
Wicks Boiler Co.
R. T. Ford Co.
Murphy Iron Works
White Wire Works
S. J. Macey Co.
Natt, Bareham & McFarlane
Kingsford Foundry & Machine Co.
H. H. Babcock
Yates Coal Co.
Vacuum Oil Co.
Chamberlain Rubber Co.
Mathews & Boucher
Willsea Works
Sterling Oil Co.
W. H. Herriman Co.
Caffery & Evans
Schwalb Coal Co.
Dan. Sohn Machine Co.
Jenkins & Macey
John D. Foster Co.
C. Thayer
Sidney Hall's Sons
McClave-Brooks Co.
Rochester Motor Co.
W. A. Wilson Machine Co.
American Oil Co.
James Gilbert
Wm. Summerhays' Sons
O. L. Goodenough
C. A. Tuke
Judson Governor Works
F. B. Callister

Auburn was chosen as the meeting place for the 1915 convention

* * *

To convert B.t.u. per pound of coal to calories per kilogram, divide the number of B.t.u. by 1.8; to convert calories per kilogram to B.t.u. per pound, multiply the number of calories by 1.8.

At the New York State N. A. S. E. Convention, Rochester, N. Y.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Lancaster & Jefferson Electric Co., Lancaster, N. H., will install a new boiler. Walter C. Colby is superintendent

The Crum Quarry Co., engine room and boiler house at Bradford, R. I., was destroyed by fire June 2. Loss, $15,000.

The United Illuminating Co., New Haven, Conn., will construct a new power house at Grande Ave. and Haven St. The estimated cost is $90,000.

Plans are being prepared for the erection of a municipal electric-light plant for Bath, N. Y. The cost is estimated at $50,000.

At a recent election at Binghamton, N. Y., bonds for $148,000 for the installation of a municipal electric-light plant were voted.

The Middleville Electric Light Co., Middleville, N. Y., is in the market for a 50-hp. boiler and engine.

New equipment will be installed at the municipal electric-light plant at Emporium, Penn. A 150-hp. gas engine, a 2200-volt generator and a switchboard are included in the equipment.

SOUTHERN STATES

Explosion and fire destroyed the power plant of the Meridian Light & Ry. Co., Meridian, Miss. Loss, $25,000.

Plans are being prepared for the installation of an electric-light plant in South Fulton, Tenn. R. C. Houston & Co., Exchange Bldg., Memphis, are the engineers.

CENTRAL STATES

Bids will be received by the commissioner of purchases and supplies, Cleveland, Ohio, until June 26, for furnishing equipment for the municipal electric-light plant. F. W. Ballard is commissioner.

The board of education, Fostoria, Ohio, will issue bonds for $20,000 to improve the heating systems of the public schools.

According to press reports the Chicago City Ry., Chicago, Ill., will build a new substation at 8205 South Halsted St. The estimated cost is $30,000.

According to press reports the Jacksonville Ry. & Light Co., Jacksonville, Ill., will construct a power plant estimated to cost $75,000. W. B. Miser is superintendent.

Plans are being prepared by R. Messmer & Bros., 1004 Majestic Bldg., Milwaukee, Wis., for the construction of a power plant, heating and lighting systems for the Milwaukee County Tubercular Sanatorium, Milwaukee.

WEST OF MISSISSIPPI

It is reported that the Minneapolis General Electric Co., Minneapolis, Minn., will make extensive improvements to its plant. R. F. Pack is general manager.

H. A. Dalbey, Hopkins, Mo., will construct an electric-light plant at Hopkins.

POWER

Vol. 39 NEW YORK, JUNE 30, 1914 No. 26

The Jungle Job

By Berton Braley

I said to myself, "I am through pioneering,
I'm sick of the wilderness, lonely and rough,
I'm sick of the graders' camp, built in a clearing,
I'm weary of laborers, hairy and tough;
I'm tired of the outfit, the bed and the ration,
The steam-shovel's puffing, the shock of the blast--
I want to go back where there's civilization,
The fun and the frolic I knew in the past.

"The life that has savor and vim in,
The sights and the noises of towns,
The laughter and lure of the women,
The glitter of jewels and gowns;
I'm done with this business forever,
I'm off to see 'cities and men',
And once I have landed, I'll never
Come back to the 'Jungle' again."

So I made for the city of wonder and glamor
The city whose glory had shone in my dreams,
I plunged with delight in its hurry and clamor,
Its welter of hopes and ambitions and schemes;
I reveled again in the food and the raiment,
The music and lights and the movement and mirth,
And I said to myself, "There is no form of payment
Can tempt me again to the outposts of earth.

But in spite of the pleasuring places,
In spite of the vast city's thrill,
The spell of the unconquered spaces
Came following after me still;
At night it would suddenly wake me
By day it would whisper and then
I knew it was trying to make me
Come back to the Jungle again.

I had thought that the softness of cities would tame me
I fought with the thrall of a life I reviled,
But the lure of the game I had played overcame me
—The struggle with Nature far out in the wild.
The flesh-pots were sweet, but they never could hold me
I packed up my kit and I made for the trail,
And now I believe what the Old Timers told me,
"The spell of the wilderness never can fail."

I'm back to the "furthermost farness,"
I'm way, way "ahead of the steel,"
I'm wearing my engineer's harness,
The gravel is under my heel;
The dreams of the city still bind me,
The call of it comes to my ken,
But somehow I left it behind me,
I'm back to the "Jungle" again.

Coon Rapids Development

SYNOPSIS—Five vertical single-runner waterwheels to develop 10,500 hp. on an average head of 17.5 ft. Output of plant to serve Minneapolis.

As shown in the accompanying summary of generating and substations, the Northern States Power Co. controls and operates large interests developing power by water and steam. According to the statistics, there is now in operation 76,677 electrical horsepower in generators, driven by 31,500 hp. of steam turbines, 12,600 hp. of engines and 34,925 hp. of waterwheels. By far the largest part is developed within a radius of 75 miles from Minneapolis.

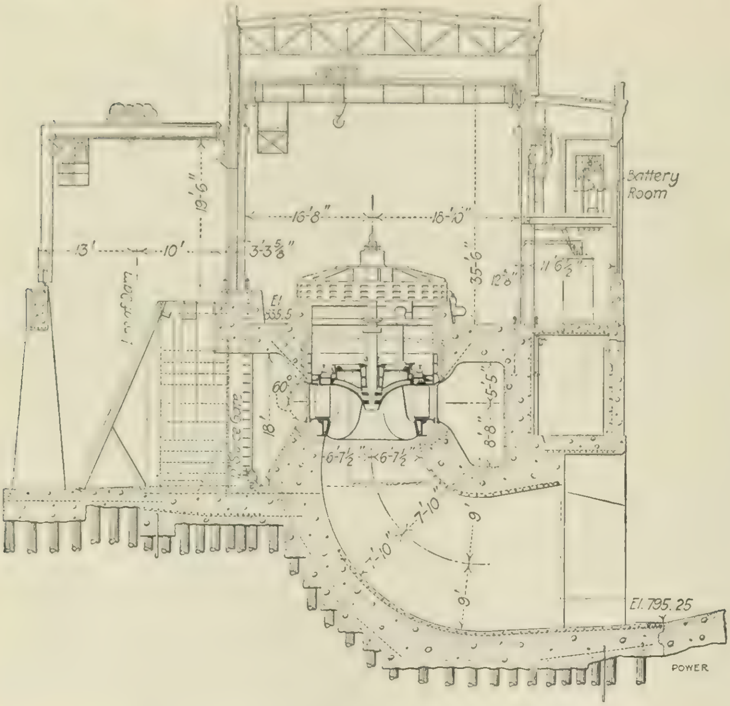


FIG. 1. TRANSVERSE SECTION THROUGH PLANT

The properties here are divided into four main divisions, designated as Stillwater, Minneapolis, St. Paul and Mankato-Faribault. The several municipalities in each of these main divisions are connected by high-tension transmission lines with the main generating stations of the division. The city of Minneapolis and the towns in this division are connected by high-tension transmission lines to the hydro-electric stations at Taylors Falls and St. Anthony Falls, known as the Main Street Station, and to the large reserve steam station at Riverside, Minneapolis. The entire division is also interconnected through a high-tension trunk line with the steam power house of the St. Paul division. Similar interconnecting systems exist between the hydro-electric and steam stations of the Stillwater and Mankato-Faribault divisions. Within the year it is intended to interconnect all of these divisions, so that a transfer from one hydro-electric station to another will be possible and permit a number of the smaller steam stations to be shut down.

The latest addition to the Minneapolis division, not included in the foregoing summary, is the development at Coon Rapids, which is on the Mississippi River, about six miles north of the city limits and 11 miles from the Main Street station. H. M. Byllesby & Co., engineers and constructors, have already finished the dam and the power house is under way. By the first of September, it should be in full operation.

The plant is to have an initial capacity of 10,500 hp., made up of five 2100-hp. units, with space for two more, so that eventually 14,700 hp. will be developed. A three-phase transmission line will connect the plant with Minneapolis, and it is intended to build a second line to Anoka. The location of the site relative to the other plants, with the exception of those of the Mankato-Faribault division, is shown in Fig. 1.

The feature of the plant is the low head, which, from previous data taken at St. Anthony Falls, will vary from 13 to 20 ft., and average 17.5 ft. To utilize this head to advantage, vertical single-runner waterwheels were designed by the Allis-Chalmers Co. to turn at 62 r.p.m. The wheels will be directly connected to the General Electric generators rated at 1625 kv.a. and designed to deliver to the station bus three-phase, 60-cycle current at 2300 volts. By delta-connected transformers the tension will be increased to 13,200 volts to lessen the cost of transmission. There are seven transformers having a total capacity of 13,000 hp. and space is provided for three more. The generators are of the suspended type and, due to the low speed, are of large size. Two 300-kw., induction-motor-driven exciter sets will furnish excitation, one to act as a spare. A waterwheel unit was not considered necessary, due to the connection with the other stations. A remote-controlled, electrically operated

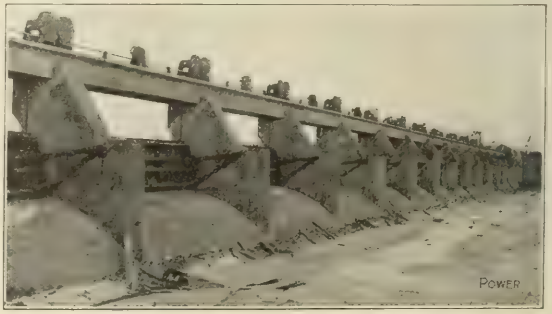


FIG. 2. PART OF DAM, SHOWING CONCRETE CREST AND TAINTER GATES

switchboard will be installed and a small storage battery for operating the oil switches and emergency lights. The layout of the plant is shown in the plan view, Fig. 3, and in the sectional elevation, Fig. 1. The building itself, 202x49 ft., will be of concrete, steel and brick.

crest. They will pass all water not used through the wheels and will be so operated as to maintain a uniform-head water level. The spillway has been designed to pass 80,000 sec.-ft., although 60,000 sec.-ft. is the maximum stream flow recorded. The draft tubes, which are 12 ft. 6 in. in diameter at the wheel and widen out as they proceed toward the tail race, have been designed for a capacity of 1320 cu.ft. per sec. at the average head of 17.5 ft.

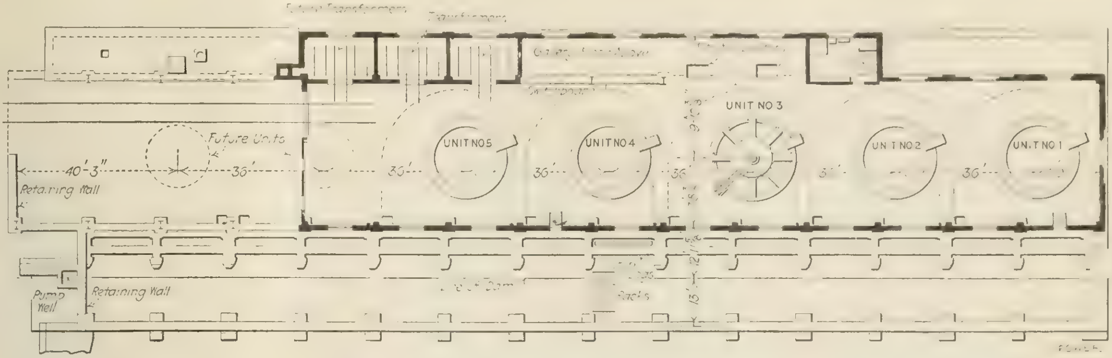


FIG. 3. GENERAL PLAN OF SUPERSTRUCTURE

As the dam passes over a small island in the river at this point, the river has two channels, one wider and more shallow than the other. Across the former channel a spillway-concrete dam of the gravity type, 1000 ft. long, was built. The power house, measuring 500 ft. with the retaining section of the dam, was built across the narrower channel; a 560-ft. earth embankment makes the total length of the dam over 2000 ft.

For its full length the gravity spillway section of the dam is surmounted by 28 Tainter gates, each being 33 ft. long and weighing six tons. These gates, shown in Fig. 2, raise the pond level 7½ ft. over the concrete

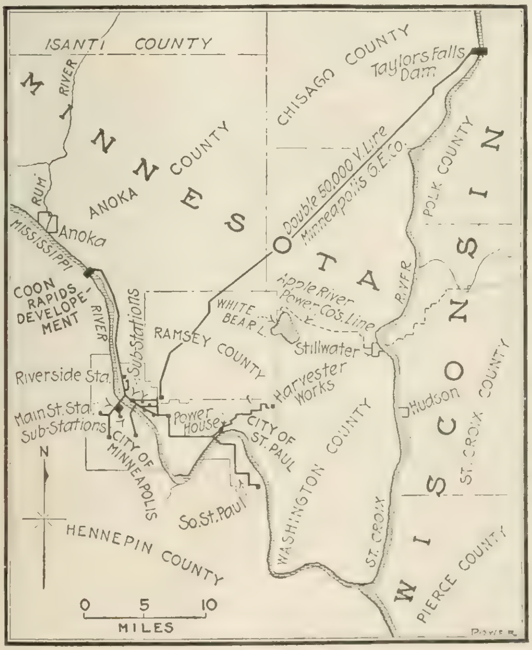


FIG. 4. TRANSMISSION LINES, NEAR MINNEAPOLIS, OF NORTHERN STATES POWER CO.

SUMMARY OF ELECTRICAL POWER PLANT EQUIPMENT OF NORTHERN STATES POWER CO.

Location	Boiler Hp.	Engine Hp	Water Wheels Hp	Steam Turbine Hp	Rating of Generators E.Hp.	Transformer Hp.	Motor-Gen. Hp.
Cannon Falls, Minn...			1,800		1,470	3,600	
Cuba City, Wis.	......	......	......	......	......	1,340	
Darlington, Wis.						200	
Dilworth, Minn.	......					334	
Dundas, Minn.	......					27	
East Grand Forks, Minn						40	
Faribault, Minn.	600	775	125		900	1,340	
Fargo, N. D.	2,248	2,080	......	400	2,480		365
Galena, Ill.	2,430	3,670		2,680	6,350	5,350	134
Grand Forks, N. D.	2,668	2,280	......	600	3,030	795	134
Hazel Green, Wis.	......	......	......	......	......	2,680	
Janesville, Minn.	......	......	......	......	......	134	
Lindstrom, Minn.	......	......	......	......	......	134	
Kasota, Minn.	......	......	......	......	......	535	
Lake Crystal, Minn.						100	
Mankato, Minn.	600	1,910	......	......	1,340	2,140	
Minot, N. D.	1,040	700	......	......	670	......	
Minneapolis:							
Taylors Falls	......	......	25,200	......	20,000	21,450	134
Riverside...	6,000			16,100	16,100	20,000	
Main			3,400		2,610	8,000	800
Substation A.	......	......	......	......	......	20,520	
5th St.	450	535	......	......	5,875	5,340	
Garfield	......	......	......	......	......	4,000	
6th St							2,980
Mis Substations						12,260	
Morristown, Minn						100	
Northfield, Minn.	100	150			154	535	
Platteville, Wis.	610	160			160	1,340	
Randolph, Minn						240	
Rapidan, Minn			2,200	......	2,010	3,350	
Red Lake Falls, Minn	150	150	400	......	240		
Riverdale, Wis...			1,000	......	667	800	
St. Paul, Minn	5,600	......	......	10,720	10,720	9,400	
Manhattan Sub						1,200	1,070
Merriam Pk						800	
Shakopee, Minn						400	
Shullsburg, Wis						400	
Somerset, Wis			800		667	1,000	
S. St. Paul, Minn	265	190			234	800	
Stillwater, Minn	640			1,000	1,000	1,600	
Waseca, Minn						400	
Waterville, Minn						700	
White Bear, Minn.						400	
Zumbrota, Minn..						700	
Total	23,401	12,600	34,925	31,500	76,677	134,484	6,217

The total does not include equipment for the Coon Rapids generating station which will be in operation late in 1914, and is as follows:

Location	Boiler Hp.	Engine Hp	Water Wheels Hp	Steam Turbine Hp	Rating of Generators E.Hp.	Transformer Hp.	Motor-Gen. Hp.
Coon Rapids			10,500		10,500	13,000	[illegible]

◆

Alabama Coal Production in 1913—The production of coal in Alabama in 1913 was 17,678,522 short tons, valued at the mines at $23,083,724, according to figures compiled by E. W. Parker, of the United States Geological Survey, in coöperation with the Alabama Geological Survey. The increase compared with 1912 was 1,577,922 short tons in quantity and $2,254,472 in value.

Gatun Hydro-Electric Plant

SYNOPSIS—Description of hydro-electric plant utilizing the surplus water of Gatun Lake, which forms part of the Panama Canal. This plant has a maximum capacity of 6000 kw. and furnishes electricity to the entire Canal Zone.

◆

Heretofore, interest has centered chiefly on the construction of the Panama Canal. Now that this work has been practically completed and regular service is about to be instituted, attention turns to the operating features, in which electricity plays a most important part. The enormous water storage afforded by the artificial Gatun Lake, fed by the Chagres River, will not only carry vessels the greater part of the distance across the Isthmus at 85 ft. above sea level, and provide water for raising and lowering them through the locks, but it will also supply the hydro-electric station at the Gatun dam. This will furnish electricity for operating the locks, towing the ships through them, lighting the entire Canal Zone, operating the coal-handling plants, drydocks and machine shops at Cristobal and Balboa, and will eventually run the Panama R.R.

To insure continuity of service, the steam station at Miraflores, erected a few years ago for construction work, will serve as a standby plant.

The electricity is generated at 2200 volts and is sent at 44,000 volts over a double transmission line across the Isthmus to Balboa and Cristobal. There are four 44,000-2200-volt substations, one each, stepping down at Balboa and Cristobal and up or down at Gatun and Miraflores, depending on which of the two plants is supplying power. The voltage is further stepped down by thirty-six 2200-240-volt transformer stations at the locks and others at the two cities mentioned.

The crest of the Gatun dam has a length of 8000 ft. and an extreme width of 2100 ft., the height above the normal lake level being 30 ft. Since the gross head available varies from 91 ft. during flood periods to 79 ft. during the dry season, the plant has been designed to develop full output at an effective head of 75 ft.

Water is taken from the lake through passages 12 ft. wide, fitted with iron racks to prevent trash from entering the pipe lines. It is then admitted to the pipe lines through three 10.5-ft. head gates. Each gate is driven by a 15-hp. motor automatically controlled by a limit switch on one of the gate stems and also by a float; the operation is essentially as follows:

Assuming the gate to be closed, the switch is thrown at the power house and the motor starts to open the gate. When the latter has opened sufficiently to fill the pipe line, in about 5 min., the limit switch opens the circuit and stops the motor. The gate remains in this position until the pipe line is full and the water rises in the 36-in. air vent just below the gate, when it actuates a float switch and again closes the motor circuit, thereby causing the gate to be opened fully. The gate is closed by reversing the main switch at the power house. If necessary, the gates may be hand-operated.

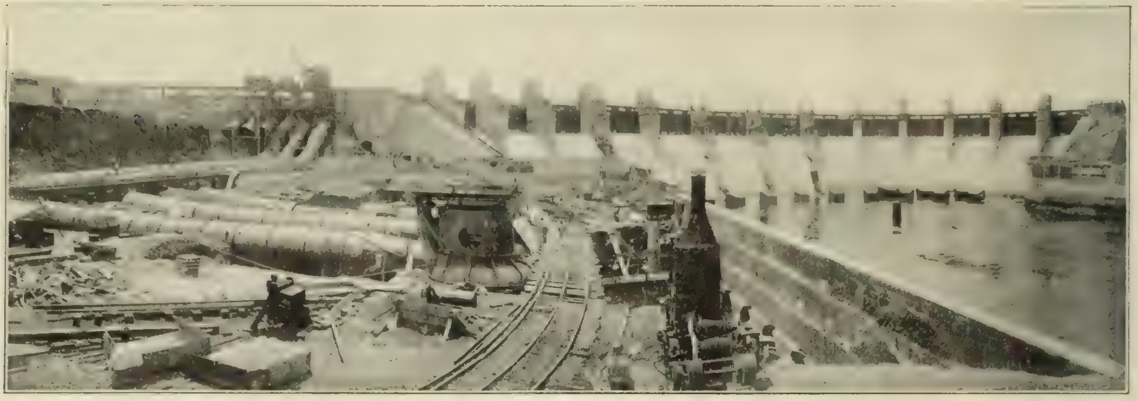


FIG. 1. PANORAMIC VIEW OF PLANT UNDER CONSTRUCTION, SHOWING PIPE LINES AND TURBINES IN PLACE

Pipe lines 10.5 ft. in diameter and 420 ft. long lead from the gates to the turbines to which they are attached by 90-deg. bends. Each of the pipe lines is arranged for attaching a pitot tube, while its unit is in service.

POWER HOUSE

The building is of concrete, with a Spanish tile roof, and measures 61x137 ft., with an extreme height of 74 ft. It is designed on the unit principle to admit of future extension and consists of a single room open to the roof. The turbine pit is 6 ft. below the main floor and there are two galleries devoted to the switchboards, oil-switch compartments, reactance coils and other electrical equipment, as well as the office and a small machine shop for repair work.

GENERATING UNITS

There are three main generating units, each consisting of a 2000-kw. vertical generator driven by a 50-in. single-runner Francis turbine, rated at 3600 hp. when operating under an effective head of 75 ft. and at a speed of 250 r.p.m. The center line of the runners is 20 ft. above tail water, and the discharge is through steel-lined concrete draft tubes 71 in. in diameter at the turbine and increasing to an elliptical section of 9x17 ft. at the outlets. A roller thrust bearing mounted on top of the generator carries the weight of the revolving parts of both the turbine and generator. The turbine is so designed, however, that, when running at full capacity, the runner exerts an upward thrust of 10 tons, thereby relieving the thrust bearing of that amount of load.

Oil for the thrust bearing is supplied by a small pump geared to the main turbine shaft, and a tank is provided below the pump to receive the overflow from the bearing.

Each turbine is controlled by a Pelton oil-pressure governor, mounted on the distance rings and driven by bevel gears from the main shaft. Tachometers are directly connected to the governor heads. The governors are fitted with small electric motors for varying the speed of the main units for synchronizing purposes, and a device is provided on each governor for varying the permanent drop in speed from no load to full load.

The wicket gates for controlling the supply of water to the runners are steel castings with hand-finished surfaces. Each has its pivot stem extended upward through a packing gland, and is fitted with an operating lever. All the gate levers are connected to the gate ring by means of bronze links, and the ring is connected to the governor rockshaft. The water passages on each side of the gates are provided with renewable rolled-steel wearing plates.

The generators are of the revolving-field type, and each is provided with a direct-connected exciter. Current is generated at 2200 volts, three-phase and 25 cycles, and each machine is guaranteed to deliver 2000 kw. at 80 per cent. power factor and a temperature rise of 40 deg. C. above room temperature, and an overload rating of 2500 kw. for two hours with a temperature rise of 55 deg. C. On the official tests they showed an efficiency of 95.1 per

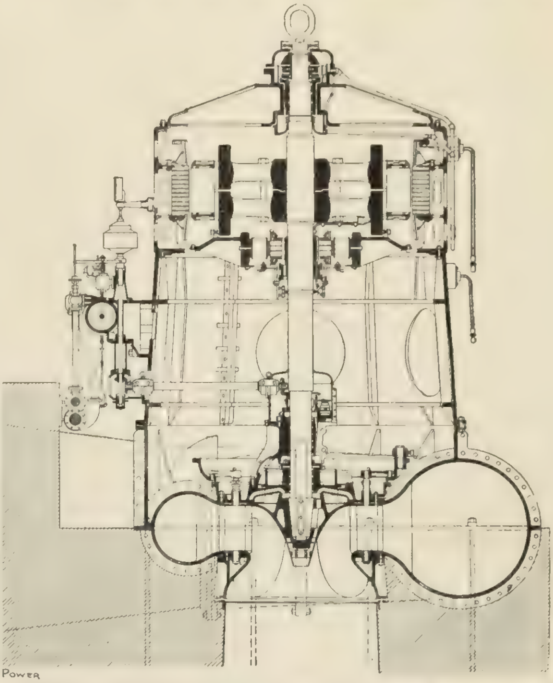
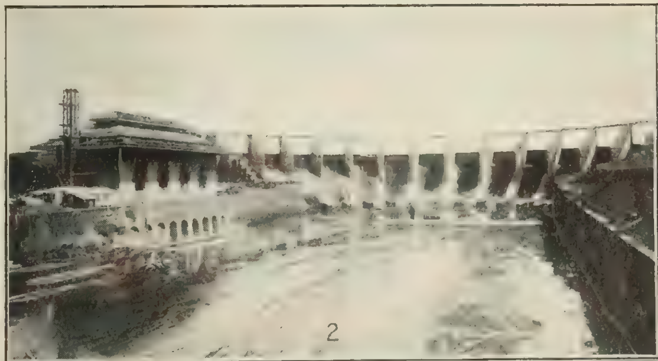


FIG. 5. SECTION THROUGH ONE OF THE MAIN UNITS



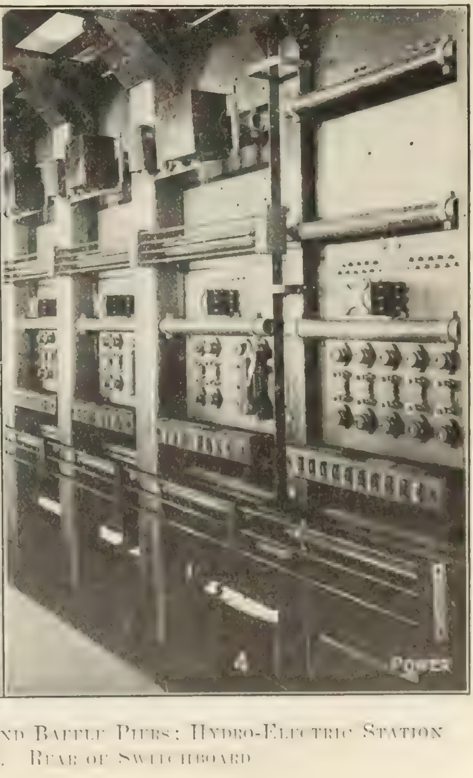


FIG. 2. SPILLWAY DAM, SHOWING CREST GATES, OGEE DAM AND BAFFLE PIERS; HYDRO-ELECTRIC STATION ON LEFT. FIG. 3. TURBINE ROOM. FIG. 4. REAR OF SWITCHBOARD

cent. at 2000 kw., 94.3 per cent. at 1500 kw. and 92.5 per cent. at 1000 kw., the power factor in each case being 80 per cent.

Besides the direct-connected exciters, there are two motor-driven exciters, each consisting of a 100-kw., 125-volt generator and a 150-hp., 2200-volt, 25-cycle, squirrel-cage induction motor. The exciters may also be used for charging the control battery.

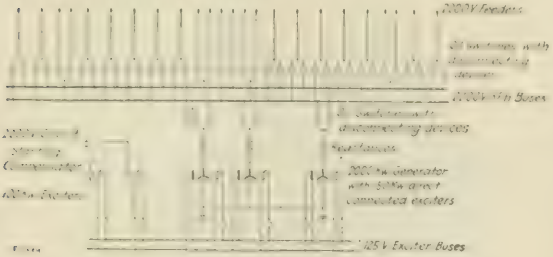

2200V Feeders
Oil switches with disconnecting devices
2200V Main Buses
Oil switches with disconnecting devices
Reactances
2000 kw Generator with 50 kw direct connected exciters
Compensator
100 kw Exciter
125 V Exciter Buses

FIG. 6. DIAGRAM OF CIRCUITS

Current-limiting reactances are provided to give 5 per cent. reactive drop at 2500 kv.-a. Besides serving to reduce the shock on the generator winding, in case of a short-circuit, these reactances will render the operation of synchronizing easier and safer.

A double busbar system of connection is employed in both the generating stations and the substations.

SWITCHBOARDS

The main switchboard, in the upper gallery, is of the benchboard type, with a vertical rear board for the relays, meters, etc. The space between the front and the rear board is inclosed by a grille. On top of the switchboard is a second story for the electrically controlled generator and exciter rheostats. There are five panels, the first controlling the exciters, the next three the generators and the fifth the 21 outgoing feeder circuits. That the operator may always have a clear idea of what he is doing and thus avoid mistakes in switching, the system of connections is represented by dummy busbars of polished copper on top of the bench. The voltage regulator, synchroscope and clock are carried on a separate pedestal.

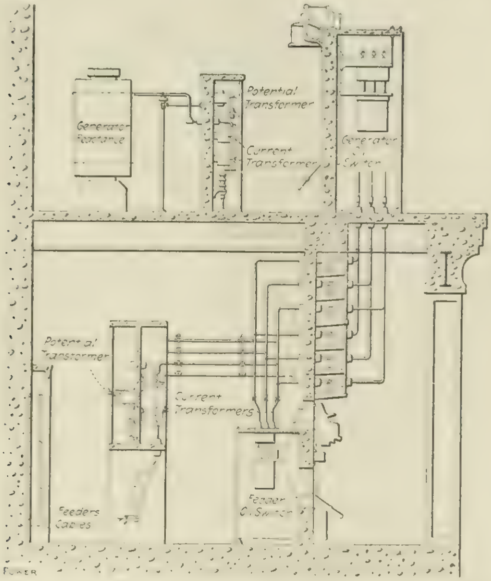


FIG. 7. GALLERIES WITH BUSBAR COMPARTMENTS AND SWITCHING EQUIPMENT

Although the exciters are controlled from the benchboard, the exciter and field switches are mounted on a separate board, so as to make the exciter connections as short as possible.

BUSBAR AND SWITCH COMPARTMENTS

All the busbar and switch compartments are of concrete. From the generator oil switches on the second gallery, connections run through the floor to the busbar compartments below, on which level are also the feeder oil switches and the compartment for the instrument transformers and cable bells; this is shown in Fig. 7.

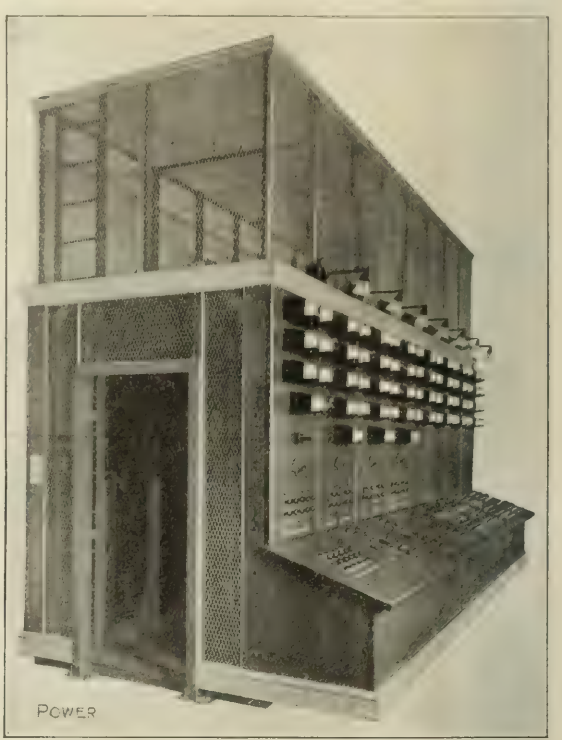


FIG. 8. INSTRUMENT AND CONTROL BOARD

The 2200-volt oil switches are all solenoid operated and are provided with mechanism for readily disconnecting them for cleaning or repairs. For the hand-operated switches, a pipe framework supports vertical metal guides, which carry the switch-operating mechanism and slate base. On the guides is mounted a lever and toggle device by which the switch and base can be raised and lowered. When the switch is lowered it is completely isolated from the circuit, and when raised, it always goes to a fixed height, where it is latched. An interlock prevents it from being raised or lowered unless its contacts are open.

The complete hydraulic equipment was designed and built by the Pelton Waterwheel Co., and the electrical equipment by the General Electric Co.

Another Boiler Explosion Due to Breathing

On Monday, June 8, at 6:43 a.m., a water-tube boiler exploded in the power plant of the Meridian, Miss., Light & Power Co., killing one, injuring two and inflicting some $20,000 worth of property damage.

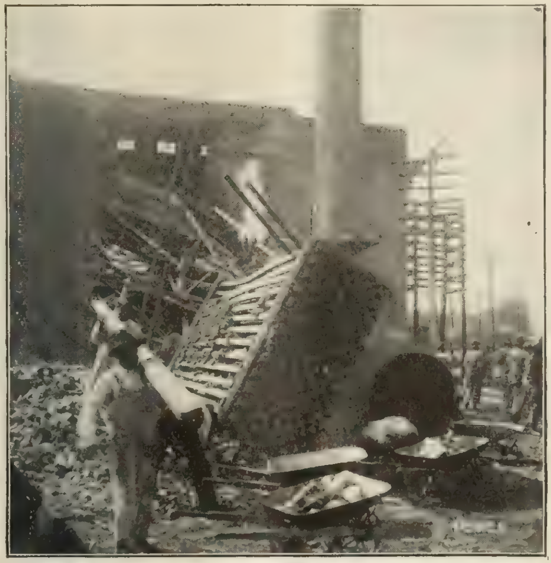


FIG. 1. VIEW OF THE BOILER, SHOWING THE TUBES AND HEADERS INTACT

The boiler was a 250-hp. Heine, built 11 years ago. It contained 138 three and one-half-inch tubes 18 ft. long and the drum was 48 in. in diameter and 22 ft. long; both heads and shell were of ½-in. sheet. The pressure at the time of the explosion was 155 lb.

The explosion was caused by the failure of the rear drum-head, which broke out in a circular rupture along the heel of the flange as seen in Figs. 1 and 2. These two illustrations also show that the tubes were not injured. The head was bumped to a radius of 60 in. as was the practice of the Heine company for all diameters at the time the boiler was built. A tendency to crack where the radius changes abruptly having been observed, the practice was modified in 1905 by adding one-eighth of an inch to the thickness of the heads, and in 1908 the radius to which heads are bumped was changed from 60 in. for all diameters to the diameter of the shell. The appearance of the fracture indicates clearly that the rupture started on the inner surface of the head and extended outward through the sheet until separation occurred. The line of fracture followed almost a true circle around the bend of the flange.

It is a clear case of the effect of the fatiguing action of countless movements of the head about the line at which an abrupt change of shape occurs in flanging, of which there have been a number of recent examples. When the explosion happened the boiler turned a complete somersault and went entirely through the brick wall, completely wrecking the boiler house, as shown in the illustrations, and so badly damaging the power house as to require reconstructing that end of the building

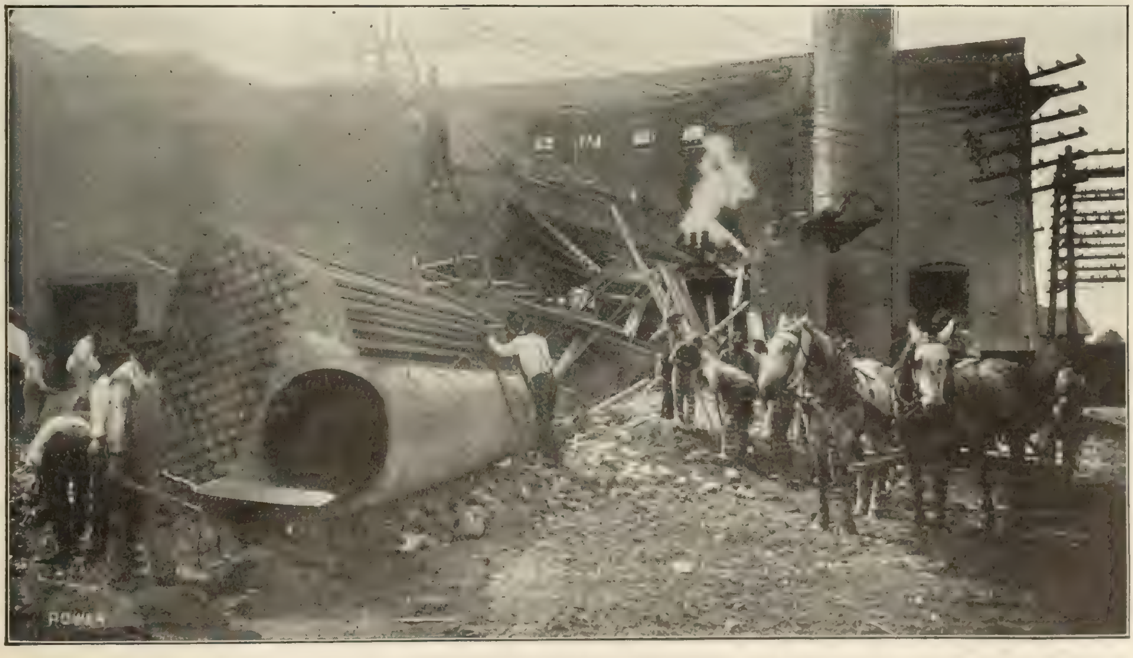


FIG. 2. RESULT OF A BOILER EXPLOSION AT THE MERIDIAN LIGHT & POWER COMPANY'S PLANT, MERIDIAN, MISS.

Speed Variation of Shunt Motors

By H. M. Phillips

SYNOPSIS—The variations in speed of a shunt motor with the temperature of the fields and with the load, also the effect of speed variation on the commercial applications.

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It is generally assumed that a shunt motor runs at approximately constant speed under all loads within its capacity. Few purchasers seek further information, few salesmen can give anything much more definite without reference to the factory and, in the writer's opinion, but few factories can give complete and definite information without first conducting a series of tests; and yet the subject is of considerable importance.

For almost any class of work there is one best speed, a fact upon which the efficiency and production experts lay great stress. Falling below that speed means a corresponding loss of output, and the least that an excess of speed can do is to cause a loss of power proportional to the increase; in many cases, the power consumed rises much more rapidly than the speed, to say nothing of the evil effects likely to be produced on the tools or their product.

Effect of Temperature on Speed

One point to which little attention is ordinarily given is the increase in speed due to temperature. It generally requires from five to eight hours of operation under full load to bring the fields to a constant temperature, during which time the speed is constantly rising. In some motors the total rise will not exceed 3 per cent., while in others it may go as high as 45 per cent. The variation in speed between starting throughly chilled on a winter morning and the end of a day's run on a hot summer day will be materially greater. The increase is by no means constant during the time required for the temperature to reach its highest value. It is almost invariably much greater during the first hour of operation than for subsequent periods, although exceptions are occasionally found.

It is obvious that the increase of field temperature will be rapid at the start, but slow during the latter part of this period, and the resistance of the field windings increases practically uniformly with the temperature, roughly, about 0.4 per cent. for each degree Centigrade. The increase in speed, although due to diminution in field current caused by this rise in resistance, is by no means proportional to the diminution. One motor may be so designed that the iron in its fields is nearly saturated when operating under normal conditions, in which case there will be little speed variation with temperature as the weaker current is able to give about all the magnetism that the fields are capable of carrying. A different design may work with the fields far below the point of saturation, in which case a change in field current will produce a nearly proportional change in magnetism and an inverse change of speed. A motor may have its fields fairly well saturated when cold but be considerably below saturation when hot; then a given change in temperature will have a greater effect on the speed after the fields are well heated than when they are cold.

Although saturated fields are advantageous in their effect on the change of speed with temperature, they work in the opposite direction when variations in line voltage are considered. It is generally assumed that the line voltage is constant, but that plant is fortunate which is not subject to variations of 5 per cent., while 10 per cent. is not uncommon. If the iron were absolutely saturated at the lowest voltage at which the motor would be called upon to operate, the speed would be directly proportional to the voltage. If the fields were so weak that the magnetism varied directly in proportion to the field current, there would be practically no change of speed with ordinary changes of voltages. Neither of these conditions can exist in a commercial motor, but one or the other may be approached to an extent that will make a considerable difference in the speed variation of two different motors.

Variation of Load

In the majority of cases the variation of speed with changing load is of less importance than the cases already noted; but here also will be found a marked difference in the characteristics of commercial motors. A few instances will be found where a simple shunt motor runs at a slightly higher speed under full load than on no load; the same pecularity is more frequently found with interpole motors. For the other extreme, there are motors that show an increase of 15 per cent. or more between full load and no load. An increase of speed with the load is seldom if ever desirable, as it is likely to lead to an unstable condition.

Aside from the comparatively few cases where it is demanded by the nature of the work, close speed regulation is apt to prove an unnecessary hardship both on the motor and on the driven machinery. The response of the electric current to a change in load is practically instantaneous, more rapid than the best mechanical governor for steam or other power, and the result is that there can be no momentary slackening of speed to relieve heavy strains, such as may be introduced by the sudden acceleration of reciprocating parts, slightly defective gears, hard spots in the material being worked or carelessness by the operator. One is not likely to appreciate how violent these fluctuations may be until a sensitive ammeter is placed in the circuit of a motor giving close regulation; in fact, sometimes the ammeter may be too slow or "dead beat" to show the full value, and one may be surprised to find the circuit-breaker being thrown on what are apparently low currents, or may blame the motor for sparking when the fault is at least partially that of the load it is attempting to carry.

Going to the other extreme, we will find shunt motors that show a speed variation of 15 or 20 per cent. between full load and no load; though such high figures are generally found only on very small motors or those designed for variable speed. For shunt motors, a variation of approximately 5 per cent. appears to be about the average for reliable makes, but the extremes are by no means confined to low-grade machines.

It is generally assumed that for shunt- and compound-wound motors the reduction in speed is directly proportional to the load; that if there is a drop of 8 per cent. from no load to full load there will be 2 per cent. drop at one-quarter load. Performance curves are frequently plotted by taking the speeds at full load and no load and drawing a straight line through the two points. It is safe to say that this straight-line characteristic is never obtained in a commercial motor, although where the total variation is small, no material error is likely to be introduced by its use. In the majority of motors the drop in speed is most marked between no load and quarter load; frequently half of the full-load drop will be found between these points, and cases have been observed where the drop at quarter load is greater than at full load, the latter condition, however, is rare.

Another common characteristic is an abrupt falling off in speed when the motor is overloaded; sometimes this may commence before the full-load point. In the majority of cases there is a considerable drop in speed from no load to quarter load, a comparatively uniform but less rapid decrease between quarter and full load with a total of about 6 per cent. at full load, and a more rapid decrease beginning at some point between full load and 25 per cent. overload. The variations, however, take a wide variety of forms; some cases have been noted where there is a fall in speed from no load to quarter load, a rise between quarter and half load and a fall at points beyond half load.

It is difficult for the purchaser to obtain information prior to an actual test on the individual motor, as to the character and amount of speed variation with load. A manufacturer may be willing to guarantee that the variation will not exceed a given amount, 10 per cent. being a common figure, but he is usually silent as to the performance within that figure, and a low variation may be a serious defect; or nearly all of the variation may be between no load and quarter load, which amounts to much the same thing. Having obtained one motor of a given make that is entirely satisfactory is not necessarily an indication that a second one will be so; if either the speed or the horsepower be different, there may be quite a radical change in the speed variation. There are differences in the electrical properties of iron that will cause one motor to differ from another; slight variations in the setting of the brushes, which may be accidental, or wrongly employed to bring the motor to its proper speed, will also affect the speed variation. Finally, after a period of service, the condition of the commutator and brushes may alter the original characteristics.

Commercial Applications

The use of compound-wound motors is, for the most part, confined to rolls, shears, shapers, planers, presses and machines equipped with flywheels, where their use is almost essential for satisfactory service. Their speed variation from full load to no load is usually in the vicinity of 5 per cent., but almost any desired amount can be obtained if specified. Where a variation of over 10 per cent. is not objectionable, the use of compound motors is apt to give better results and require less repairs than shunt-wound motors, and the slight difference in cost should prove a good investment.

From the foregoing it will be seen that the purchaser who has well defined ideas as to what he wants in regard to the speed characteristics of his motor will find it difficult, if not impossible, to find a manufacturer to comply with them. The usual guarantee that a motor will give "satisfactory" service will hardly cover the case unless one can stipulate just what is to constitute satisfactory service. If a motor operates its machine successfully but gives slightly less output for the machine or consumes a little more power than the best possible motor, it would not be ordinarily considered unsatisfactory, although either of those conditions may mean the loss of many dollars in a year. A motor whose commutator must be turned once a year, or even once in six months, may not be defined as unsatisfactory, but one that will go for two years or more without turning is certainly much better. Although the performance curves given in the bulletins of reliable manufacturers are generally those of one or several motors that are supposed to be fair representatives of the entire line, motors of a different rating in either speed or horsepower may depart materially from these results.

A variable-speed motor giving a ratio of two to one or over, and provided with the necessary controlling apparatus, is much more costly than a constant-speed motor; but almost any constant-speed motor can be fitted with a field rheostat at slight expense so as to enable one to raise its speed as much as 10 per cent. above its normal rating with no injurious effect on the motor. Such an arrangement, although seldom used, is desirable sometimes; the rheostat being divided into quite a large number of steps will enable one to get the exact speed within the maximum and minimum limits desired to compensate for the rise due to heating, for variable voltage, for pulleys that do not give exactly the desired ratio, and to experiment on the possibilities of obtaining increased output through a slight increase of speed. If so desired, the rheostat may be put under lock and key, so that the speed can be adjusted only by the foreman or some other authorized person, the motor being started and stopped by the operator in the usual manner.

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Draft over the Fire

To burn coal in a boiler furnace requires air, and if efficiency is sought this air must be supplied in the proportion suitable to the coal on the grate. The quantity of air carried to the fuel depends on the strength of the draft over the fire for a given thickness of fuel bed. It is important then to have the draft right at this point. The draft at the stack, when taken in conjunction with the reading over the fire, indicates the drop through the setting and breeching, but if only one reading is to be taken, it should be the latter.

When referring to the draft of a boiler it has been common to give a reading taken at the base of the stack. This is misleading as it is lower than the draft at a point in the stack just above the breeching or in the breeching itself on the stack side of the damper, and is no gage of the draft intensity over the fire. It is not surprising, therefore, that resistances proportionally large have been interposed between the stack and the furnace. This results in reducing the draft over the fire too low for good combustion.

The common faults have been breechings too small to carry the gases without undue resistance, breechings with too many turns, dampers located so that they interfere when fully open with the flow of gases, restricted areas in boilers that were baffled and in some cases the combustion chamber has been clogged with checkerwork or other needless resistances. Even when properly proportioned and with its base straight from one end to the other, a breeching interposes considerable resistance. It is usual to allow one-tenth of an inch of water for every hundred feet of run and two-tenths is better for the usual conditions. Every 90-deg. bend adds five-hundredths to this amount and an equal resistance is set up when the gases of one boiler pass the uptake of another. The resistances offered by the damper and the other factors mentioned will depend on the installation, but in a plant of ordinary size, anywhere from ⅜ to ¾ in. of draft may be wasted by needless obstruction to the flow of gases.

With so much resistance cutting down the draft, the average stack has not been high enough to produce the best results, and particularly when the fuel is highly volatile, as then a strong draft over the fire is needed to pull in enough air for good combustion. In many of these cases remodeling the breeching, or perhaps the entire gas passage, will make the stack ample for average conditions and it may give some leeway for different qualities of fuel or a thicker fuel bed.

Of late it has been considered good practice to reduce the number of boilers on one stack and to replace right-angle turns with sweeping bends where the uptake enters the breeching and at the juncture of the breeching and the stack. This lessens the drop from the interference of gases and the eddying caused by a right-angle turn. In some recent plants the breeching has been eliminated entirely. An uptake covering two boilers leads to a stack at the center. There is no run of breeching to cut down the draft, no turns to cause further reduction, and interference is eliminated as the gases, when they meet, are flowing in the same direction into a stack of ample area. Outside of the stack the resistance is limited to the setting, and with proper design this may be low, so that the greater part of the draft produced is available over the fire.

With such construction there is no occasion for a high stack when the fuel is to be burned at ordinary rates of combustion. In plants subject to sudden and large demands of steam, making it necessary to run the boilers for a time at 200 to 300 per cent. of rating, an intense draft and a high stack to produce it will be required. Most of the draft, however, will be available over the fire, and in periods of normal load it can be held in check by dampers.

Often in an existing plant an investigation of draft conditions will save the installation of a new boiler. The matter is not of such minor importance as the individual losses would indicate. It is important then to get the draft down to the fire, where it is needed. Keep down the resistance in the breeching and setting and make the stack as effective as possible.

* *

Steam-Electric Power Plant at Hauto, Penn.--IV

By Warren O. Rogers

SYNOPSIS—Energy from the turbo-generators is raised from 11,000 to 110,000 volts by means of oil-insulated water-cooled transformers placed in fireproof compartments. A portion of the energy developed at the power station is used, at 11,000 volts, for local service at the mines. There are remote-control oil switches on the 11,000- and the 110,000-volt circuits. Electrical energy is transmitted 26 miles to the Siegfried substation, where it is stepped down to 22,000 volts for commercial use.

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Electrical energy from the Hauto power plant is transmitted to a substation at Siegfried, Penn., at 110,000 volts. The distance is 26 miles and the current is sent over duplicate three-cable circuits supported on a line of steel towers spaced about 600 ft. apart. Anchor towers are placed at all turns in the line and about every half mile on a straight line. Each transmission circuit consists of three standard copper cables, each 250,000 circ. mils, or about ⅝ in. diameter. The three cables of each circuit are placed one above the other in the same vertical line, the distance between each being 10 ft., with the bottom cable never less than 22 ft. from the ground. They are supported by suspension insulators, each consisting of six 10-in. disks. At the anchor towers the cables are anchored by two strings of seven-unit insulators yoked together for greater mechanical strength. At every third tower, as a precaution against the cables sagging when loaded with frozen sleet, two sets of insulators are hung at 45 deg. from the vertical.

At the substation the electrical energy is reduced by means of step-down transformers from 110,000 volts to 22,000 volts, at which pressure it is delivered to the distributing circuits and transmitted to the power customers.

As stated in a former article, energy is generated by the turbo-generators at 11,000 volts and is delivered to the low-tension busbar through circuits which include impedance coils for the protection of the generator in case of short-circuits. The 11,000-volt busbars are placed in brick-inclosed cells, as shown in Fig. 25. Fig. 26 is a view of the oil switches and circuit-breakers used for controlling the 11,000-volt circuits. The oil switches are directly above the busbar compartments, and on a level with the turbine-room gallery.

From the generator busbars two circuits are tapped off, one feeding the three transformers and the other connecting with an 11,000-volt loop bus. The low-tension busbars are connected in a loop and provision has been made for a loop bus for the 110,000-volt circuits when more units are added.

The 110,000-volt transfer bus is so arranged that any outgoing feeder may be connected to any set of transformers, or two or more feeders may be connected to one or more sets of transformers. Two auxiliary 11,000-volt busses supply energy to the auxiliary motor circuits in the power house as well as the local load in the vicinity of Hauto.

Both switches and circuit-breakers which control the 11,000-volt and the 110,000-volt energy are controlled and operated electrically with current supplied by storage batteries at 125 volts.

All 11,000- and 110,000-volt oil switches are controlled from a benchboard on the turbine-room gallery. All power circuits are reproduced diagrammatically by dummy busbars and miniature switches mounted on the main benchboard. The position of each switch is indicated by a pilot lamp on the benchboard in the dummy system, a green light signifying that the switch is open and a red light that it is closed. This gives the operator an exact representation of the existing connections of the power circuits between the alternators and the busbars and between the busbars and the transmitting circuits.

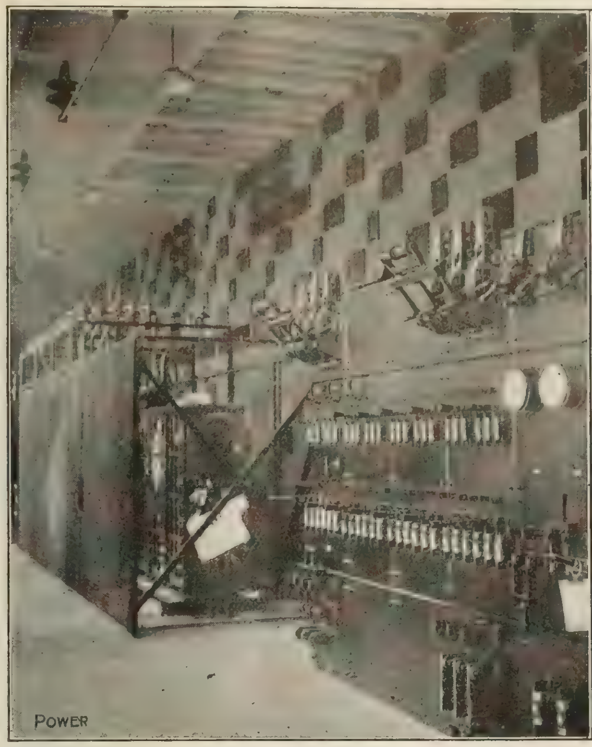


FIG. 25. LOW-TENSION BUSBAR COMPARTMENTS AND STATION SWITCHBOARD

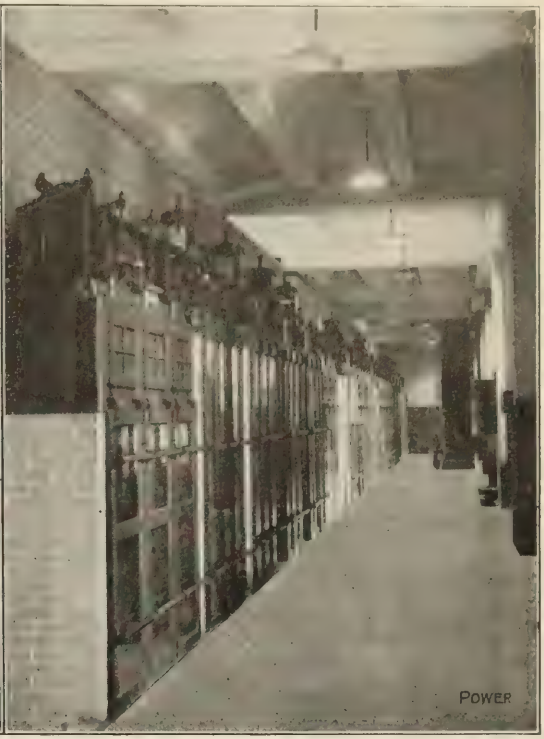


FIG. 26. LOW-TENSION OIL SWITCH AND CIRCUIT-BREAKER ROOM

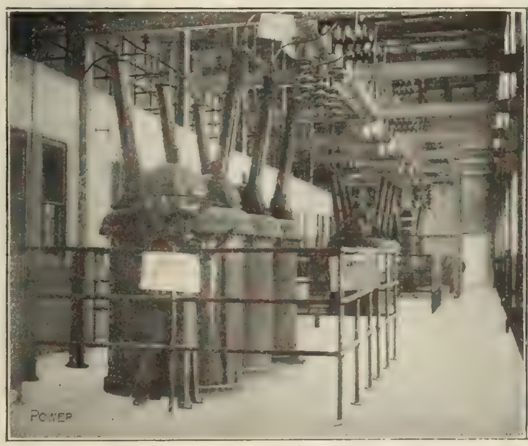


FIG. 27. SINGLE-PHASE 110,000-VOLT OIL SWITCHES AND HIGH-TENSION BUSBARS

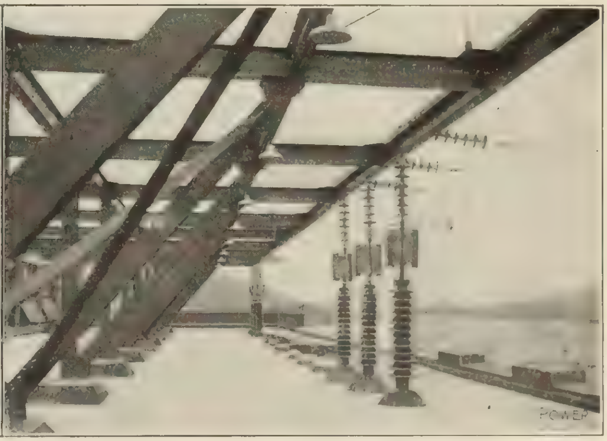


FIG. 28. METHOD OF INSULATING THE OUTGOING HIGH-VOLTAGE LINES AND THE ANCHOR FRAME

On suitable panels behind the benchboard are instruments for recording the power voltage, current, frequency and power factor of the various circuits.

There are nine oil-insulated, water-cooled transformers, each of 3350-kv.-a. capacity, for raising the potential from 11,000 to 110,000 volts; each is in a fireproof compartment. The low-voltage leads come through the wall from the 11,000-volt bus compartments and the high-voltage conductors pass up through the ceiling to the high-potential switches and bus room. Each transformer is provided with wheels which rest on a track to facilitate moving the transformer. Outside the building there is a track along the length of the building on which a transfer car runs, the top coming level with the floor of the transformer room. This arrangement provides means for the ready removal and installation of any transformer. Each group of three transformers is capable of delivering in continuous service 10,000 kw.

Each transmitting circuit has a set of three single-phase, 110,000-volt oil switches, Fig. 27. These are in the high-tension switch room above the transformer room and on a level with the floor of the low-tension circuit-breaker and oil switches. The high-potential conductors are of 1-in. brass tubing, carried on porcelain insulators and separated not less than 3 ft. from every part of the building except where they pass through the floor and the roof of the high-tension busbar room; here the conductors are insulated by special bushings.

The method of insulating the high-tension outgoing lines where they pass through the roof is shown in Fig. 28, also the massive construction of the anchor frame, erected on the roof of the high-tension switch room. Choke coils are shown between the two vertical strings of insulators.

Each conductor of the transmission circuit is equipped outside of the power house with a lightning arrester of the electrolytic, horn-gap type. These arresters are at the foot of the first dead-end tower. The small arresters are connected to the 11,000-volt circuits supplying electrical energy in the near vicinity of the power plant; the larger arresters, to the 110,000-volt transmission lines.

Twenty-five-cycle energy is transmitted to the Siegfried substation from the Hauto plant over the double-circuit, 110,000-volt transmission line. From the substation two double 22,000-volt circuits extend to Martin's Creek and Coplay. The Martin's Creek line is built for 110,000 volts as far as Nagareth in anticipation of a substation near this point when the load requires it. There are also two 11,000-volt lines running to Lansford, Penn.

Ammonia Condensers--III

By Fred Ophuls

SYNOPSIS—In the Sept. 2 and 30, 1913, issues of Power, *the various types of ammonia condenser in common use were described. The present article points out distinctive features of these condensers and touches briefly on their relative efficiency as cooling and liquefying apparatus.*

* * *

The general law which describes the heat-transfer phenomena in a condenser states: The heat rejected in a given time into the cooling water is equal to the product of the square feet of effective cooling and condensing surface; the rate at which heat is transmitted through a square foot of this surface in a given time for each degree of mean temperature difference between the ammonia and the cooling water, and the mean temperature difference between the ammonia and the water. This general law can be expressed in symbols as follows:

$$H = S \times k \times t_d \qquad (1)$$

In this formula

H = Heat rejected by the condenser into the cooling water, generally expressed in B.t.u. per hour;
S = Square feet of effective cooling and condensing surface;
k = Rate of heat flow in B.t.u. per sq.ft. of effective cooling and condensing surface per hour per degree Fahrenheit mean temperature difference between the ammonia and the water (called the heat-transmission coefficient);
t_d = Mean temperature difference between the ammonia and the water.

The total heat H rejected from the condenser per hour is made up of heat quantities rejected during three distinct changes in the state of the ammonia. Two of these heat quantities can be practically zero in certain types of refrigerating systems and specially designed condensers. The three heat quantities are the following:

(1) The heat removed from the superheated ammonia gas as it enters the condenser in cooling it to a saturated vapor at the ammonia pressure in the condenser.

(2) The heat removed from the saturated vapor in liquefying it at the temperature of saturation.

(3) The heat removed from the liquid ammonia in cooling it below the temperature of saturation, or liquefaction.

In the ammonia-absorption system in which, for economical reasons, the superheated ammonia vapor as it passes from the generator is first made to flow through a rectifier or dehydrator to reduce or practically eliminate the water vapor, the resulting anhydrous ammonia vapor is reduced to within a few degrees of the temperature of liquefaction. For this reason, the amount of superheat removed in a condenser of this system is so small compared with the heat of liquefaction that it can be neglected.

An ammonia condenser can be so designed that the final temperature of liquid anhydrous ammonia leaving it is practically the same as the temperature of liquefaction, so that there is practically no heat removed from the liquid ammonia. A condenser designed for liquefaction only is a special apparatus, applicable for use in special cases, and while it would be more simple to analyze than one embodying all the changes in the state of the ammonia, the more complicated apparatus is a better example of actual practice.

Equation 1 can be amplified by dividing the total heat quantity H into its constituent elements, as stated below in equation 2.

$$H = H_s + H_l + H_f = S \times k \times t_d \qquad (2)$$

In this equation

H_s = Heat of vapor superheat;
H_l = Heat of liquefaction;
H_f = Heat of liquid forecooling.

For comparing the magnitude of these values, the following figures may be given as representing a common condition of operation:

Condenser or liquefying pressure, lb. gage per sq.in.	184
Temperature of superheated ammonia entering the condenser, deg. F.	250
Temperature of liquid ammonia leaving condenser, deg. F.	90

For these conditions of operation, the heat removed from the condenser per pound of ammonia liquefied will be as follows:

$$H_s = (250 - 95) \times 0.53 = 82.2 \text{ B.t.u.}$$
$$H_l = 495.3 \text{ B.t.u.}$$
$$H_f = (95 - 90) \times 1.1 = 5.5 \text{ B.t.u.}$$

Total heat removed.......... 583.0 B.t.u.

To show the heat and temperature distribution as commonly found for some of the condenser types described and illustrated in these articles, the heat-distribution diagrams in Figs. 1 to 4 are shown. In these diagrams, horizontal distances represent quantities of heat in British thermal units per pound of ammonia liquefied and the vertical distances the temperature changes in degrees Fahrenheit of the ammonia in the condenser and the water used for cooling and liquefying it.

Fig. 1 shows the heat distribution for simple open-air ammonia condensers, as in Figs. 1 and 2 of the article appearing Sept. 2. In this type of condenser, the hot ammonia gas enters the condenser at the point where the cooling water is showered over it. This condition is illustrated by the points *a* and *e*, Fig. 1, the zigzag line *abcd* representing the temperature change in the ammonia, and *ef* that of the cooling water.

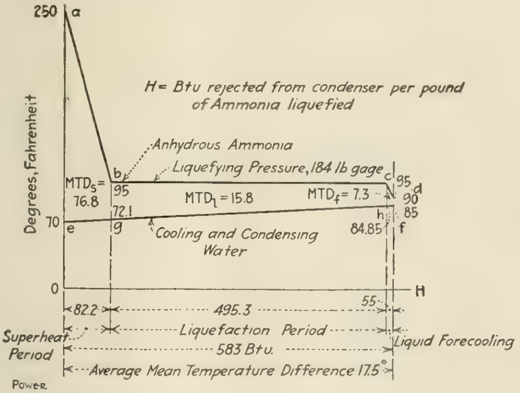

250
a
H= Btu rejected from condenser per pound of Ammonia liquefied
Anhydrous Ammonia
Liquefying Pressure, 184 lb gage
b
c
95
d
90
85
MTDs= 76.8
95
72.1
MTDl = 15.8
MTDf = 7.3
h
84.85
f
70
e
g
Cooling and Condensing Water
Degrees, Fahrenheit
0
H
82.2
495.3
5.5
Superheat Period
Liquefaction Period
Liquid Forecooling Period
583 Btu.
Average Mean Temperature Difference 17.5°
Power

FIG. 1. HEAT-DISTRIBUTION DIAGRAM FOR OPEN-AIR AMMONIA CONDENSERS

As the ammonia and water flow downward, the ammonia is cooled to the liquefaction point at *b* and the water rises in temperature to the point *g*. At *b* the ammonia is in the form of a saturated vapor and in its flow further down through the condenser it is liquefied, until finally at *c* all the ammonia is liquid. During the liquefaction period the temperature of the water rises from *g* to *h;* after this, if the liquid ammonia has not reached the outlet from the condenser, it will be further cooled by the water to the temperature *d* and the temperature of the water will rise to *f*.

Applying to this diagram the heat quantities given and assuming that the superheated ammonia gas enters the condenser at 250 deg., that liquefaction takes place at 95 deg. F. and the liquid is undercooled 5 deg., it will be found that if 2 gal. of 70-deg. cooling water are showered over the condenser per minute per ton of actual refrigerating effect of the system, its temperature at the end of the superheat period will be 72.1 deg.; at the end of the liquefaction period 84.85 deg.; at the end of the liquid-forecooling period 85 deg.

Having determined this temperature change, the logarithmic mean temperature difference for each period can be calculated. In this case it is 76.8 deg. for the superheat period, 15.8 deg. for the liquefaction period and 7.3 deg. for the liquid-forecooling period.

As the ammonia during the superheat period is gaseous and during the liquid-forecooling period a liquid, the heat-transmission coefficient for these periods is far less than for the liquefaction. However, the quantities of heat removed are also small, and for this reason a proper basis for the comparison of condenser performance can be obtained by assuming the heat-transfer coefficient constant for the three changes in the state of the ammonia. With this assumption, it is possible to find the combined mean temperature difference for the three periods by use of the following formula

$$t_{dm} = \frac{H}{\frac{H_s}{t_{ds}} + \frac{H_l}{t_{dl}} + \frac{H_f}{t_{df}}} \qquad (3)$$

In this equation the subscripts *s, l* and *f* indicate the superheat, liquefaction and liquid-forecooling periods, respectively.

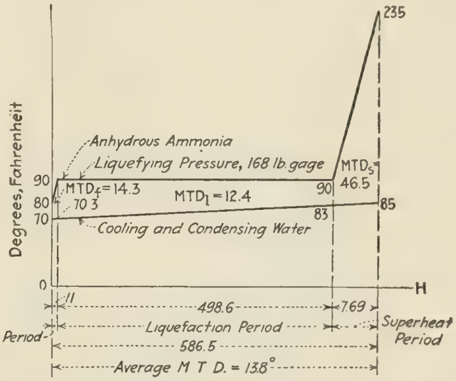


FIG. 2. HEAT-DISTRIBUTION DIAGRAM FOR DOUBLE-PIPE AND SPIRAL-COIL CONDENSERS

From this equation we find for the conditions represented in Fig. 1 a combined mean temperature difference of 17.5 deg. F.

Fig. 2 shows the temperature and heat distribution for the open-air, double-pipe and spiral-coil condensers of the counter-current type illustrated in Figs. 3, 4, 7, 8, 9 and 10 of the previous articles when supplied with the same quantity and temperature of cooling water used for the simple open-air condenser. The combined mean temperature difference in this case is 13.8 deg. F.

To a casual observer it would appear from these results that for the same square feet of effective cooling surface the condensers from which Fig. 1 was plotted would give a greater condensing capacity than those to which Fig. 2 refers. This, however, is not the case, for the following reasons:

From equation (1) it will be seen that the mean temperature difference is not the only determining factor in the transfer of heat, but that the magnitude of *k* is just as important. From a condenser in which the combined mean temperature difference is small, just as much heat can be rejected as from one where the combined mean temperature difference is large, provided the value of *k* is larger in the former than in the latter case. Experiments have shown that the value of *k* varies as the square root of the average mean speed of the fluids in the condenser. The fact is that in the condensers for which Fig. 2 shows the heat distribution, the mean velocity of the vapor and the efficiency of the condensing surface is greater than in those to which Fig. 1 refers. The result is a lower liquefying pressure and a lower final liquid temperature for the same quantity and temperature of cooling and condensing water. The use of this type of condenser affects the efficiency of the refrigerating system as a whole in two ways. The greater forecooling of the liquid results in a reduction in the weight of refrigerant that must be circulated per ton of refrigeration produced and the lower liquefying pressure results in a smaller steam consumption for operating the refrigerating machine.

Fig. 3 shows the temperature distribution for the atmospheric condensers illustrated in Figs. 5 and 6 of the article appearing Sept. 2. It will be seen that their construction, while not as good as that of the condensers illustrated in Figs. 3, 4, 7, 8, 9 and 10, is better than that of the simple open-air condensers.

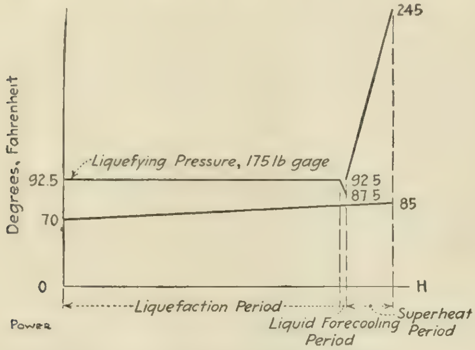


FIG. 3. HEAT-DISTRIBUTION DIAGRAM FOR ATMOSPHERIC CONDENSERS, TYPE C

Fig. 4 shows the temperature distribution for a double-pipe ammonia condenser in which the ammonia headers and water headers are located at the opposite ends of the apparatus. This construction produces parallel flow in the same direction for the ammonia and water in each pipe, whereas the general flow through the condenser of the ammonia and water is counter-current. This condition of operation is indicated by the broken line showing the temperature changes in the ammonia.

A general equation giving the value of the heat-transmission coefficient for condensers is as follows:

$$k = a\sqrt{v}$$

where

a = Constant which must be determined by experiment for each type of condenser;

v = Average mean speed of the ammonia and water in feet per second.

Contrary to the ideas generally advanced in steam practice, the velocity of the ammonia vapor in this type of condenser affects the value of k. Experiments made at the works of the De La Vergne Machine Co., New York City, have shown that for open-air condensers, where the water flows perpendicularly to the ammonia vapor, the value of k is almost entirely dependent on the speed of the vapor in the condenser and, so far as could be determined, independent of the speed of the water.

For double-pipe condensers and other types in which the ammonia and water flow in parallel currents, and either in the same direction or counter-current, the value of k varies directly as the square root of the mean average velocity of the two fluids.

These statements can be readily proved without giving actual figures of test results, for Louis Block found some time ago that by throttling the inlet valves of ammonia condensers so that the valve was barely open, as good, if not better, results were obtained. The reason for this is that when these valves are wide open, the pressure in the condenser is nearly that in the discharge pipe, and on account of the large area of the condenser pipes, the average velocity of the vapor in the condenser is low. This velocity directly affects the value k and a large temperature difference is necessary to produce results. On the other hand, if the inlet valves on the condensers are throttled, the pressure in the condenser itself falls considerably below the pressure in the discharge pipe and the vapor speed in the condenser will be considerably increased, raising the value of k and improving the results, even though the mean temperature difference with the valves partly closed will be less than when they are wide open. Therefore, by so regulating the inlet valves of the ammonia condenser, a point can be found where the ammonia-discharge pressure and the final fluid temperature will be a minimum.

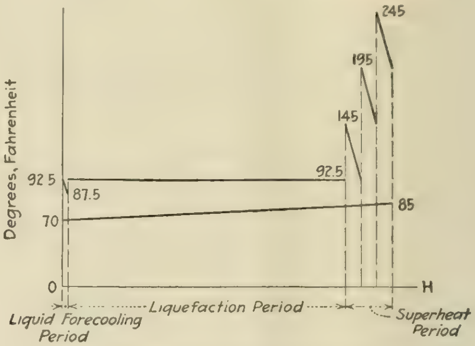


FIG. 4. HEAT-DISTRIBUTION DIAGRAM FOR DOUBLE-PIPE AMMONIA CONDENSERS

In Fig. 6, in the Sept. 2 issue, a special type of open-air ammonia condenser was illustrated. This condenser is equipped with an ejector A, which is ostensibly used for mixing some of the liquid ammonia condensed with the discharge vapor coming from the compressor before it passes to the top of the apparatus. It is claimed that the mixture of vapor and liquid will result in a better heat transfer in the apparatus than could be obtained with the vapor only. This statement is contrary to the laws of heat transfer, and if this condenser produces better results than a well constructed apparatus on the lines illustrated in Figs. 3, 4, 7, 8, 9 and 10, it is only due to the resulting increase in circulation in the condenser. The fact is, that in all condensing apparatus, whether used for steam or any other condensible vapor, the best results are obtained with constructions in which the liquid condensed is removed as soon as formed.

The Block type of ammonia condenser, Fig. 4, is a modification of the De La Vergne open-air condenser,

Fig. 3. The advantage of the former construction lies entirely in the better forecooling of the ammonia liquid before it flows to the liquid receiver. The construction otherwise is not ideal as a condensing apparatus, because all the liquid must pass up through all the condenser pipes before it can be discharged into the liquid receiver. The claim for the efficiency of this condenser is the same as that made for the atmospheric condenser shown in Fig. 6. Experiments have shown that the increase in efficiency of this condenser over the simpler open-air condenser is entirely due to the higher average speed of the vapor. The liquid, if not removed as soon as formed, fills up part of the space in the pipes and restricts the available area for the flow of the vapor, so that the average speed of the vapor is maintained nearly constant throughout this condenser. For condensers where the liquid is drawn off at various points, the speed of the vapor decreases as more and more of it condenses. On the other hand, in the latter type there is more surface available for condensation, so that actually this type of condenser, if properly designed and installed, will give better results than any other type heretofore described.

Theoretically, there is no difference between the operation of the Block type and the standard double-pipe type of ammonia condenser illustrated in Fig. 8 of the article appearing Sept. 30, except that in the former the ammonia vapor passes up through the condenser, whereas in the latter, the vapor enters at the top and the liquid is drained off at the bottom.

The spiral-coil type of surface condenser illustrated in Figs. 9 and 10 have been used largely in connection with absorption refrigerating machines and have proved efficient. The only objection to their use is the difficulty of cleaning the spiral coils of scale deposits, particularly when the quality of the cooling and condensing water is such that at the temperature in the condenser a hard scale is formed.

These condensers are so constructed that the liquid drains from the cooling surface practically as soon as formed, and, therefore, are of a construction which conforms to the best practice as indicated by theory. If this design were so improved that the velocity of the ammonia vapor would be greater than is the case in the construction at present used, better results could be obtained. As they are now constructed, the value of the heat-transmission coefficient k varies almost entirely with the speed of the cooling and condensing water through the coils for the reason that the speed of the ammonia vapor is small.

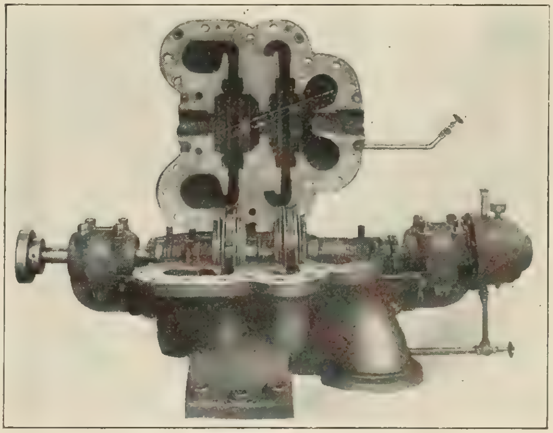
Fig. 11, in the Sept. 30 issue, illustrates an application of the standard steam condenser for use in liquifying ammonia. In this type, the velocity of the ammonia vapor is also small as compared to the speed of the water flowing through the tubes, and for this reason the value of k varies as the square root of the speed of the water, being practically independent of the speed of the vapor.

Figs. 12, 13 and 14 illustrate types of submerged ammonia condensers and but little test data are available on which to analyze their efficiency. They are at this time not much used, as a great deal of cooling and condensing surface is necessary in their construction to obtain good results. This is largely due to the inefficient use of the cooling and condensing water. The cooling water has a tendency to short-circuit from the water inlet to the outlet, and on account of the large cross-section available for the water flow, the heat-transfer coefficient k is extremely small.

In conclusion, it is most important in designing an ammonia condenser to take into consideration the velocity of flow of both the cooling and the condensing water and the ammonia vapor. Further, the best results are obtained if the liquid is removed as soon as formed. There is, of course, a limiting speed for the flow of the water and the ammonia vapor in condensers, and this limit is found in the pressures required to produce this flow. Depending on the cost of power and the first cost of installation, the limits will vary to some extent. The cheaper the power, the higher will be the limiting speed for the water and the vapor.

Goulds Centrifugal Fire Pump

A new two- and three-stage centrifugal fire pump, designed to work against 100 lb. pressure, has recently been put on the market by the Goulds Manufacturing Co., Seneca Falls, N. Y. The pumps are designed to discharge into hose lines or for service with automatic-sprinkler systems.



Centrifugal Pump with Casing Lifted

The casing consists of two castings horizontally divided on a plane passing through the center of the shaft, as illustrated. Both the suction and the discharge nozzles are cast integral with the lower half. The upper and lower halves of the casing are bolted together and maintained in alignment by means of tapered dowel pins. Removing the upper half of the casing permits of inspecting the impellers, the shaft and the water passages.

The impellers are made of phosphor bronze, and have vanes of a shape to gain the highest efficiency when operating under the conditions for which the pump is built; they are of the nonoverload type. The hubs are fitted with removable and renewable composition wearing rings which reduce leakage to a minimum from the discharge side back to the suction side, and may be replaced when worn. The shaft bearings are of anti-friction metal, made in halves, divided on the center line, and may be removed and renewed by taking off the upper half of the bearing shell.

The stuffing-boxes are fitted with split bronze glands so designed that the water leaking through them cannot be thrown off from the shaft, but is drained into the drip pockets. The stuffing-box on the suction side of the pump has a bronze lantern water-sealing ring, through which water from the pressure side of the pump is piped, thus preventing the entrance of air into the pump.

Diesel Engines in Marine Work

The following is from a letter by a correspondent who has been chief engineer of a Diesel ship for the past eighteen months. While this particular ship has been regarded as eminently successful it has not been free from engine troubles, but these are slowly being eliminated. As expressed by the writer, "Diesel engines have come to stay and it behooves marine engineers to study them."—Editor.

*

The vessel, the machinery of which I have charge, has been in service for 18 months, the latter part of this period with considerable success. The propelling machinery consists of two single-acting, four-stroke-cycle, open-frame type Diesel engines of six cylinders each, with a diameter of 22 in., and 39-in. stroke. Although designed for about 1100 brake horsepower each, the engines indicate approximately 2700 hp. combined.

Difference of opinion exists among engineers as to the type best suited to marine work; some prefer the open frame, others the closed-in type. With the latter, of course, a clean engine room is possible, while with the former it is impossible to prevent the lubricating oil splashing onto platforms, gratings, etc., due to the high speed of the engine. Still, from a practical point of view, the open type is preferable as the bearings can be felt by the engineer and any slacking back will probably be noticed in time. Also, in overhauling, it is much simpler and quicker, and builders of this type try to conform as nearly as possible to ordinary steam-engine practice.

As regards the engine operation, the exhaust valves are generally looked upon as a weak part and require constant overhauling. On several occasions we have had the valve spindles and their guides break. This was due to the rubbing surface being too soft and not sufficiently lubricated, at the same time working too hot. It was remedied by fitting hard-steel bushings, both on the guides and spindles, by a more efficient means of lubrication and by fitting an internal pipe to insure the lower part of the chest being cooled. Since then no trouble has been experienced; yet we find it advisable to take the valves and chests out every few weeks and replace them with spare ones, a full set of which should always be carried, those taken out can then be put in order at sea. Moreover, due to working at such high temperatures, the valves and seats are apt to become warped.

The air-inlet valves give little or no trouble, neither do the fuel valves if they are not allowed to become dirty, and care is taken that the fuel is well filtered. The small valves, which automatically release the compression in the cylinders while maneuvering, must be carefully watched for dirt; a little on the spindles or valves causes them to stick, with consequent difficulty in getting the motor started.

The cylinders themselves should be well water jacketed, especially the heads. Many cylinder heads have been cracked through faulty circulation, because the valves were too crowded, leaving no space for the water to get through. This has been remedied in our case by placing the fuel valve out of the center, thus giving more freedom for the water to circulate.

Another source of trouble was the pistons, which are water cooled, the inlet and outlet being through telescopic pipes fastened on the bottoms of the pistons and working with them. Owing to the long stroke, it is difficult to keep these pipes working true, but we have now made the outer pipes, in which the telescopes work, larger in diameter to allow of more movement. Several pistons were cracked by the cold water striking directly against the hottest part. This was remedied by fitting deflecting plates inside, which forced the water to take a circular direction, the cooling then being more gradual. The pistons are about 12 in. long, each fitted with eight ramsbottom rings, with a broad white metal band on the lower part to insure a working fit in the cylinder. If not well lubricated, the rings give a lot of trouble, get fast in the grooves and in a short time are burned solid; which means that they have to be cut out with a hammer and chisel. The rings should be an easy fit in the grooves and there should be efficient lubricating pumps for forcing the oil. Then the wear on the cylinder walls will be slight. In this design, the piston is examined from the bottom, so that no shafts, levers or pipes need be disconnected, which means a great saving in time, in fact, a piston can be examined in less than an hour.

Another important part of a Diesel-engine equipment is the air-compressing plant. This in the present case consists of a three-stage compressor driven by balance levers from the main engines. The compressed air is discharged at each stage through copper coils placed in one of the main columns through which water is continually circulating, to insure the air being well cooled; the compressor pistons are very long and are lined, above the ramsbottom rings, with white metal, thus insuring a neat fit in the cylinders. Here, again, good lubrication is essential to avoid trouble. The valves must be examined and cleaned as often as possible; if allowed to get dirty, they quickly become baked. The cooling coils also give trouble at times, being liable to crack at the neck of the flange, due to the expansion and contraction. These should be washed out occasionally with benzine to get rid of the oily deposit from the lubricant, a little of which is sure to find its way in with the air, and it may have disastrous results—in fact, most of the explosions recorded of Diesel motors have been due to this cause—so that too much care cannot be used with the compressing plant.

It will be seen from what has been said that many spare parts must be carried, especially on a vessel making a long voyage.

The fuel oil used is ordinary Roumanian or American gas oil with a specific gravity of 0.890 at 15 per cent. and a flash point of 80 deg. C. In regard to the lubricating oil, only the best should be used. Inferior oils are not recommended as they give trouble, and animal oils, above all, should be avoided. We now use one kind and quality only for all purposes of lubrication, instead of three as before; this is much to be preferred as a mistake is so easily made. Following are specifications of the oil used:

Viscosity at 50 deg.	10.5
Flash point	215 deg. C.
Specific gravity at 15 deg.	0.92

It should be mentioned that all the auxiliaries are steam driven, one oil-fired boiler being fitted on deck for port use and a smaller one in the engine room for use at sea. Firing is accomplished partly by oil and partly by the exhaust gases from the engines. The boiler is of the ordinary marine type, having two furnaces, so that the gases are continually passing through one furnace, to act, in the first place, as a silencer, and in the second to utilize the waste heat from the exhaust. The second furnace is free for an oil burner, but we find it unnecessary, as with the steering and other small engines usually working at sea, sufficient steam to drive them is generated by the exhaust gases alone, which is a great saving.

In conclusion, it is my opinion that a great deal yet remains to be done before internal-combustion engines for ship propulsion have the reliability of the steam engine. However, progress will undoubtedly be made, and it behooves marine engineers to study the question, as Diesel engines have come to stay.

Calculating Evaporation Costs

By Theodore Maynz

SYNOPSIS—A set of charts for readily figuring the cost of coal, labor and ash removal per 1000 lb. of evaporation.

⁂

Engineers and engineering salesmen often need to make rapid calculations on the cost of coal, labor and ash disposal. To do this rapidly on a slide rule may give rise to errors, especially in decimal places.

The best basis for calculating power costs is probably on 1000 lb. evaporation. From this the total cost per annum may easily be figured, either from the total water records or, if these are not obtainable, from the total coal and the approximate evaporation per pound of coal.

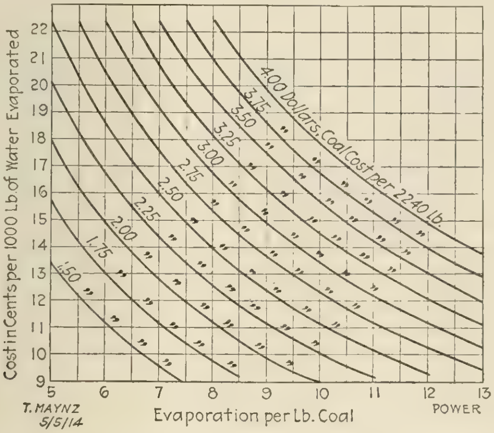


FIG. 1. COST OF EVAPORATING 1000 LB. OF COAL WITH DIFFERENT PRICED COALS AND DIFFERENT BOILER EFFICIENCIES

Total evaporation = Tons of coal × 2240 × pounds equivalent evaporation per pound of coal

Using the first chart, by means of the evaporation per pound of coal and the cost of coal per 2240 lb., delivered in the boiler room or bunkers, the cost in cents for evaporating 1000 lb. of water is easily found.

The second chart shows the cost of labor in the boiler room per 1000 lb. evaporation. This cost is based on the total labor cost per 2240 lb. of coal fired, which is probably the easiest method of arriving at this figure.

$$\text{cost of labor per ton of coal} = \frac{\text{labor cost per month (or year)}}{\text{tons of coal per month (or year)}}$$

The third chart shows the relation between the percentage of ash and refuse, the equivalent evaporation and the cost of ash removal per 1000 lb. of evaporation. A cost of 50c. per 2240 lb. of ash and refuse is the basis of cartage cost. Of course, this will vary in different localities, but this cost can easily be multiplied by some factor to take care of this difference, such as one-half cost from the chart, if the contract price for ash removal is 25c. per ton instead of 50c.

If the total ash and refuse is not obtainable, as may be the case when considering the change from one coal to another, the amount may be approximated from the coal analysis by multiplying the percentage of ash by 1.25, as this will be an average factor for fixed carbon and moisture in the ash as dumped from the furnace.

Criticism may be made that an evaporation of 10 to 12 lb. cannot be obtained with 20 to 36 per cent. ash and refuse. However, this part of the curves was put in only for convenience of extending the curves, and for keeping the chart uniform in appearance. The use of the curves is best illustrated by considering a complete problem.

A boiler plant using anthracite coal, hand fired and costing $2.50 per ton of 2240 lb. delivered; 1200 tons being used per month, at an average equivalent evaporation of 7 lb. per pound of coal, as fired. The operating labor is in three shifts, each consisting of two firemen and one coal passer, paid $2.50 and $2 respectively, seven days per week. The total ash and refuse is approximately 22 per cent., costing 40c. per ton for removal.

The use of soft coal and stokers is considered, the coal costing $3.50 per 2240 lb. delivered, the ash analysis being 8 per cent. An evaporation of 10½ lb. is guaranteed, the labor for operation being reduced to one fireman and one coal passer per eight-hour shift, at the same wage rate. What will be the cost reduction, if any?

COAL COST: Anthracite at $2.50 per ton from Chart No. 1, and 7 lb. evaporation gives 16c. per 1000 lb.

LABOR COST: $7 per eight hours = $21 per day or $630 per month. The labor cost, per ton of coal, equals $\frac{630}{1200}$ = 52½c.

From Chart No. 2, interpolate between 50 and 60c. at 7 lb. evaporation and get 3.37c. as the cost per 1000 lb.

ASH REMOVAL at 7 lb. evaporation and a charge of 50c. per ton and 22 per cent. refuse from Chart No. 3 is 0.7c.

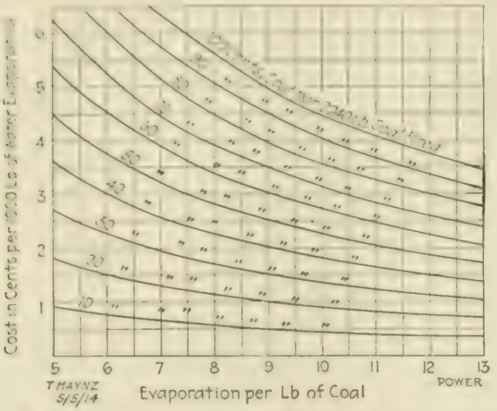


FIG. 2. COST OF LABOR PER 1000 LB. OF EVAPORATION

per 1000 lb. At 40c. per ton this will amount to ⅘ × 0.7 = 0.56c. per 1000 lb. evaporation.

Therefore, the total cost for operation is,

	Cents
Coal	16
Labor	3.37
Ash	0.56
Total	19.93 per 1000 lb. evaporated

With stokers and soft coal, from Chart No. 1, with coal at $3.50 per ton and 10½ lb. guaranteed evaporation,

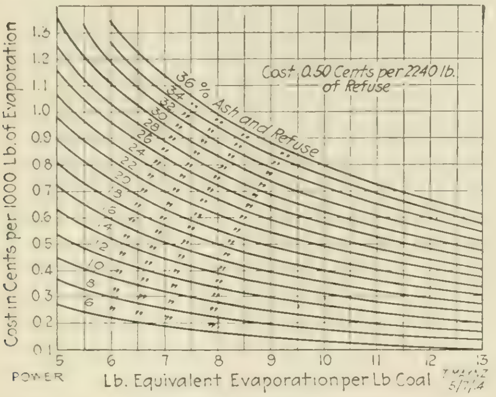


FIG. 3. COST OF ASH AND REFUSE DISPOSAL PER 1000 LB. OF EVAPORATION

the cost of evaporating 1000 lb. of water is 14.85c. The labor will cost $4.50 for 8 hr., or $405 per month.

With a new coal consumption of

$$1200 \times \frac{7}{10.5} = 800\ tons$$

per month, the labor cost will be

$$\frac{405}{800} = 50.6c.$$

per ton of coal fired. This combined with a 10½-lb. evaporation brings the labor cost to 2.2c. per 1000 lb. evaporation, obtained from Chart No. 2. From the coal analysis, the ash being 8 per cent., the total ash and refuse will be about 10 per cent. (8 × 1.25 = 10) and under 10½ lb. evaporation, from Chart No. 3, the removal cost at 50c. per ton will be 0.21c. per 1000 lb. However, at 40c. per ton the cost will be 0.17c. per 1000 lb. evaporation.

The total operating cost per 1000 lb. evaporation would be

	Cents
Coal	11.85
Labor	2.2
Ash removal	0.17
Total	17.22

From these figures the percentage saving can easily be figured for the total or for each item, or the total cost per month may be quickly obtained.

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Efficient Operation of Centrifugal Pumps

BY OTTO HAENTJENS

A well designed centrifugal pump in operation will not always be as efficient as was expected by the purchaser. The fault, however, in many cases is with the purchaser and not with the manufacturer.

Many engineers not familiar with centrifugal pumps make the mistake of allowing a substantial margin for safety when estimating the total head against which the pump has to work; although this is good practice with power pumps, it is absolutely wrong with centrifugal pumps. The manufacturer will build a pump that is most efficient at the capacity and head specified by the engineer. Supposing the engineer had estimated the total head to be 100 ft., but in operation it was found to be only 80 ft. The pump at this lower head would discharge much more water, and if this were not allowable and the speed of the motor could not be reduced, the discharge would have to be throttled, resulting in a decrease in efficiency of about 20 per cent. A more efficient way to correct the trouble is to turn down the impeller blades (not the side disks). The diffuser need not be changed.

If the head has been estimated too low, the repair becomes more costly, for besides a new impeller a new diffuser must be put into the pump. Therefore, the designer, as a rule, figures the impeller for a slightly higher head than was specified.

Every centrifugal-pump manufacturer impresses upon the purchaser the advantage of a low suction lift, tight suction piping with few bends and a slant toward the intake; yet one can find many installations where little attention has been paid to these rules. The result is poor working of the pump and a condemnation of the centrifugal pump in general.

Extreme lift or small suction piping with many bends, small foot valves and strainers cause a high vacuum at the impeller inlet. This low pressure is not sufficient to force the water at the required velocity into the impeller and the capacity and efficiency of the pump are reduced accordingly. The pump often loses the suction and has to be primed again.

Every centrifugal pump should be equipped with a vacuum gage which should be placed as close to the pump as possible. It is a good trouble indicator. If everything is all right in the suction line, the hand of the gage will vibrate but slightly; if the hand oscillates violently back and forth, it is an indication of an air leak in the suction pipe. Air usually causes a rattling noise in the pump, but this also can be caused by the diffuser, it being either too small for the capacity pumped or the diffusion vanes come down too close onto the impeller. It is good practice to have ¼ in. clearance between the impeller, and in the volute pumps without diffusion rings, the clearance between the impeller and the neck on the outlet branch should be from ¾ to 1 in. If it is less, the pump is liable to be noisy. Noisy pumps are always less efficient and should not be accepted by the purchaser.

If under normal conditions the suction gage shows, say, 10-in. vacuum, and the vacuum gradually increases and comes up to 15 or 18 in., it is time to clean the strainer and inspect the foot valve. The face area of a foot valve should at least be equal to the free area of the suction pipe and a strainer should have an area three to six times larger. If possible, a foot valve should be omitted as a defective valve can decrease the efficiency considerably.

The purchaser should insist that with the bid there should be submitted a characteristic curve showing the performance of the pump. If, for instance, the manufacturer guarantees a pump to have a capacity of 1200 gal. per min. against 200-ft. head and a best efficiency of 72 per cent., it does not mean necessarily that this efficiency will coincide with the capacity and head named. It may occur, when the pump discharges 1000 gal. per min. and the efficiency at 1200 gal. per min. may be only 68 per cent. The pump then will use about 6 per cent. more power than the purchaser figured on. A characteristic curve will show further to what extent the pump will overload the motor if the head on the discharge is diminished, as through a break in the pipe line. Twenty-five per cent. overload may be permitted, but not more, as some motors now on the market will not stand a larger overload.

Many engineers believe that a high-lift pump in order to be efficient must be equipped with diffusion rings. This is true for small capacities and high head per stage; for instance, it would not be advisable to use a two-stage pump without a diffuser to handle 300 gal. per min. against 400-ft. head, but if the head is limited to 150 ft. per stage, pumps without diffusion rings are very efficient. These pumps are usually built with a removable upper casing and permit easy access to the runners in case ships, stones or rags, etc., should have found their way into the pump and clogged up the impellers. Furthermore, the shaft and the impellers can be replaced in a very short time. This is important where no spare pumps are installed and a long shutdown would seriously interfere with the operation of the entire plant. Even if this type of pump should be a little less efficient than a pump equipped with diffusion rings, the advantages outlined above will in some plants offset this.

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Analyzing an Existing Plant*

By Osborn Monnett†

SYNOPSIS—A study of breeching arrangement and loss of draft in a plant which could not develop normal rating without smoking.

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In the last article a new plant was designed. It is frequently necessary, however, to study the draft conditions in a plant already in operation and point out the defects with the idea of improving conditions. In the accompanying illustration is shown a plant consisting of three 180-hp. horizontal water-tube boilers, vertically baffled, with mechanical stokers, on leg *A* of the breeching; one 500-hp. horizontally baffled water-tube boiler connected to branch *B* of the breeching, and two 150-hp. return-tubular boilers on branch *C*. The lengths of the different branches of the breeching are shown in the drawing. The grate surface and the dimensions of the damper openings and of the stack are also given. The problem is to determine what changes, if any, are necessary to better draft conditions.

The stack is 115 ft. high, making an available height over the breeching connections of

$$115 - 15 = 100\ ft.$$

with the arrangement of breeching shown, it would not be reasonable to expect a temperature of over 475 deg. at the stack. At this temperature 100 ft. of stack will give a draft of

$$100 \times 0.0065 = 0.65\ in.\ of\ water$$

Taking the straight run of breeching from the stack to boilers Nos. 2 and 3 as 50 ft., a draft loss of 0.1 in. can be assumed. Branch *B* will cause 0.05 in. additional loss. The right-angle bend at *K* will take off another 0.05 in., and for each of the uptakes of boilers Nos. 2 and 3, another 0.05 in. will be lost, so that in the breeching over the last boiler there will be

$$0.65 - 0.1 - 0.05 - 0.05 - 0.05 - 0.05 = 0.35\ in.$$

of draft. Below this uptake there is another right-angle turn before reaching the damper, so that a net draft at the damper of only 0.3 in. is obtained.

In the type of setting used on No. 1 boiler there is a draft loss of 50 per cent., so that the draft over the fire would be 0.15 in. Allowing 5 lb. of coal per boiler horsepower, at the normal rating of 180 hp., there will be

$$180 \times 5 = 900\ lb.$$

of coal burned per hour. The grate surface is 36 sq.ft. and the rate of combustion per square foot will be

$$\frac{900}{36} = 25\ lb.\ per\ hr.$$

Referring to the draft curve, Fig. 2, on page 808 of the June 9, 1914 issue, it will be seen that to burn this amount of coal smokelessly 0.26 in. of draft over the fire will be necessary. It is plain that it would be difficult to get rating on boilers Nos. 1, 2 or 3 without producing smoke.

In the breeching to the 500-hp. boiler there will be a loss of about 0.15 in., allowing 0.05 in. for the straight run, 0.05 for the entrance of branch *C* and 0.05 in. for the right-angle turn of branch *B*. The available draft, then, at the damper of boiler No. 4 will be

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†Smoke inspector, city of Chicago.

$$0.65 - 0.15 = 0.5\ in.$$

As there will be a drop through this type of boiler of 65 per cent. this will give a net draft over the fire of

$$0.5 \times 0.35 = 0.175\ in.\ of\ water$$

At 5 lb. per horsepower the boiler will use

$$500 \times 5 = 2500\ lb.$$

of coal per hour. With 100 sq.ft. of grate surface the rate of combustion per square foot per hour will be

$$\tfrac{2500}{100} = 25\ lb.\ of\ coal$$

At this rate the draft should be 0.26 in., so that under the present arrangements good operating conditions at rated capacity cannot be obtained on this boiler.

Considering boilers Nos. 5 and 6, the draft at the stack side of the damper of the last boiler would be 0.40, assuming a 0.25-in. drop in the breeching. The loss is made up as follows: Stack to point *O*, 0.05 in.; turn into branch *C*, 0.05 in.; from point *O* to No. 5 boiler, 0.1 in.; drop due to No. 5 breeching connection, 0.05 in., making a total loss of 0.25 in. and reducing the available draft at the stack side of the damper of No. 6 boiler to 0.4 in. With proper furnace design, the draft loss in return-tubular boilers is 47 per cent., so that the net draft over the fire on these boilers is

$$0.40 \times 0.53 = 0.21\ in.$$

The grate surface is 36 sq.ft. and the coal consumption at rating will be

$$150 \times 5 = 750\ lb.\ per\ hr.$$

The rate of combustion per square foot of grate surface per hour will then be

$$\tfrac{750}{36} = 21\ lb.$$

This calls for a draft of 0.21 in. of water, so that the draft for these boilers at rating is satisfactory.

To improve the breeching layout, starting with boilers Nos. 1, 2 and 3, the uptakes into the breeching should be eased off into long sweep bends, doing away with the right-angle turns. The draft at this point will then be improved. The turn at *K* should also be changed to a long sweep bend. In calculating the height of stack necessary for normal rating or above, branch *A* can be taken as a basis, because if the draft can be increased sufficiently here, then the draft on the other branches will be satisfactory.

A draft of 0.3 in. over the fire would take care of

$$\frac{36 \times 28}{5} = 202\ hp.$$

an overload of 12 per cent. This would necessitate a draft of 0.60 in. at the damper of No. 1 boiler. With a 0.30-in. drop from here to the stack, the draft necessary at the stack connection will be

$$0.60 + 0.3 = 0.9\ in.$$

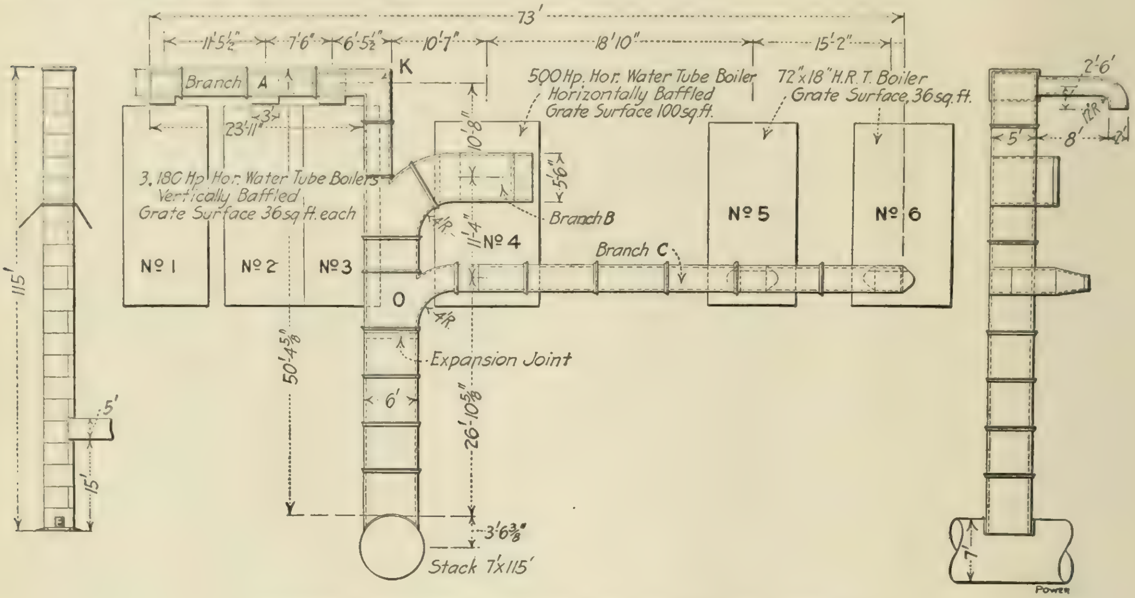
and the height of stack above the breeching connection must be

$$\frac{0.9}{0.0065} = 138.4\ ft.$$

or practically 140 ft., making a total height of stack of

$$140 + 15 = 155\ ft.$$

above the ground. This would give rating on No. 4 boiler and some overload capacity on Nos. 5 and 6.


73'
11'5½"
7'6"
6'5½"
10'7"
18'10"
15'2"
K
Branch A
3"
23'11"
500 Hp. Hor. Water Tube Boiler Horizontally Baffled Grate Surface 100 sq.ft.
72"x18" H.R.T. Boiler Grate Surface 36 sq.ft.
3, 180 Hp. Hor. Water Tube Boilers Vertically Baffled Grate Surface 36 sq.ft. each
10'8"
5'6"
Branch B
No. 4
Branch C
No. 5
No. 6
No. 1
No. 2
No. 3
O
Expansion Joint
50'4⅝"
26'10⅝"
6'
3'6⅜"
Stack 7'x115'
115'
5'
15'
2'6"
5'
8'
7'
Power

SHOWING LAYOUT OF THREE 180-HP. BOILERS AND BREECHING

AREA OF STACK

The total connected grate surface is

$$36 + 36 + 36 + 100 + 36 + 36 = 280\ sq.ft.$$

With a 7-ft. stack the ratio of stack area to connected grate surface is 38.5 to 280, or 1 to 7.27. This is altogether too high, but as ordinarily there will be at least two boilers down, the ratio will be reduced to 38.5 to (280 — 72), or 1 to 5.4, indicating that the stack will probably be large enough for ordinary use.

The layout shown must not be taken as in any sense ideal. It is given merely to show what may be encountered in practice and to indicate the method of procedure in studying an existing plant.

Editorials

Boiler-Explosion Table

Years ago, Power published certain statistics regarding boiler explosions and always has covered reports of the most important accidents. For some time it has been our ambition to get out a more complete compilation of such data, and, beginning with January, 1913, we commenced a systematic campaign to secure it. The first printed evidence of these efforts appears in this issue.

When this work was started we endeavored to bring every possible means to its assistance. Boiler-insurance companies were asked to coöperate. Our news correspondents, subscription agents and advertising solicitors were instructed to advise us of any boiler accidents coming to their knowledge. Finally, with the service of a number of clipping bureaus, we managed to get in touch with what we feel is a large proportion of the accidents to stationary boilers that have occurred in this country during the past year. A few marine boiler explosions have been covered, but all locomotive boiler accidents were omitted as not likely to interest many readers of Power. By way of explanation, it may be added that the term "explosions" has been used in its strictest technical sense to cover any unintentional escape of steam and is not confined to such as cause total destruction or dislodgment of the boiler.

For the assistance we have received from various sources we wish hereby to acknowledge our indebtedness. We would mention these friends individually if space permitted, but for repeated favors we feel that special thanks are due to the Maryland Casualty Co., the Fidelity & Casualty Co. of New York, the Hartford Steam Boiler Inspection & Insurance Co., and the Globe Indemnity Co.

When we had learned of an explosion, our work had just begun. The source of the information never gave us all of the facts we wanted, so a post card was sent to some one in the vicinity of the explosion, asking that the blanks be filled. These blanks requested the information given at the heads of the columns of the table, including date, place, plant, time of day, kind of boiler, pressure carried, size, number killed, number injured, property loss and probable cause. Failing to get an answer to one card, a second was sent to someone else, and sometimes a third and fourth, or until as many as possible of the blanks were filled. In nearly all cases fifty cents was offered and paid for the return of each card, so it can be seen that in this item alone, the campaign was expensive.

It was with considerable chagrin that we found how spotted with blank spaces the table proved to be, for the accidents of which we were able to obtain full reports were in the minority. Another thing that has disappointed us was the delay in getting the table printed. We apologize for all these very evident defects, pleading only that the work was difficult and we were inexperienced. However, we feel encouraged to promise better next time, and it will be our aim to issue the table quarterly instead of annually, and with less elapsed time between the last accident and the appearance of the table.

We expected to present with the table some comments and summaries, but are compelled from pressure on our space this week to hold them over for a later issue. The table speaks for itself as to the lessons it teaches, and will get its message to those who are inclined to study over it a little.

As always, upon any innovation, we shall be pleased to have our readers' opinions. Criticisms as well as words of approval will be very welcome, if they will help us discover in what directions the table may be improved. Let us hear from a number what they think of the value of such a table. Possibly it will not appeal to enough people to warrant our continuing to collect the information, and if that is so we want to know it, and quickly.

If we are to continue it, the help of all our subscribers and friends will be appreciated. We cannot promise a half dollar to every one that sends in a post card concerning a boiler accident, for we might pay too many times for the same report. We will, however, gladly offer fifty cents for the first card that gives the most of the information before enumerated regarding any boiler accident.

⁂

The Breathing Bumped Head

Analogous to the danger which lurks in the lap-seam joint is that present in the bumped boiler head, another instance of the failure of which is recorded on page 911.

If a piece of boiler plate is clamped in a vise and the free end moved backward and forward, a fracture will eventually occur, not at the point of greatest movement, but where the external movement is arrested and the greatest molecular distortion necessary to permit that movement occurs.

A vessel under pressure tends to assume a form having a circular section. With a lap joint, the section of this shell is not circular. Internal pressure tends to stretch the joint in such wise as to bring its center line within the circle, and if the joint is sufficiently out of true to spring out again on the removal of pressure, there will be repeated distortion about a line of flexure which will eventually result in a crack hidden between the sheets which may work its way through until the remaining sound metal is insufficient to withstand the pressure and an explosion occurs.

Many of the most disastrous recent explosions have been produced in this way. Many lap-seam joints on boilers which have been cut up have shown incipient cracks of this kind. Many lap-seam boilers, on the other hand, have lived to a good old age without developing any such infirmity. The tendency to do so is increased by lack of ductility in the material, by the manner in which the edges of the sheet which are not curved by the bending rolls are brought to the curve of the boiler, by the departure from a true circle in the finished seam, by the pressure carried, and so forth.

It is possible that more refined methods of inspection may detect incipient failure or reassure as to the safety of specific examples of joints of this type. Mr. Jeter, the chief inspector of the Hartford Steam Boiler Inspection & Insurance Company, has suggested a method of slotting the exterior sheet, which will give an indication of the impairment of a joint from this cause. A description of this will appear in the next issue.

A boiler head under pressure tends to assume a hemispherical form. This tendency is met half way by bumping the head to a radius equal to the diameter of the boiler. If it were practical to meet it completely by making the heads hemispherical, the flanges by which they were attached to the shell would be tangential to their own curve and the ideal construction would be realized. As it is, there is an abrupt change of curvature where the flange is turned down, and if the plate is so light or is bumped to so large a radius as to be subjected to considerable flexure under pressure, the fiber stress due to that flexure will be concentrated at this point of sudden change and the metal in that line will be liable to the same cracks that have made the lap seam so dangerous. The crack extends around the heel of the flange and the center of the head comes out, breaking away from the flange usually in a clean circle.

This does not mean that all or most bumped heads are dangerous. The larger the head, the thinner and more brittle the metal, the larger the radius to which it is bumped, the more abruptly it is flanged, the greater the pressure and the more frequent the fluctuation in pressure the more dangerous it will be. Owners of shells with large heads bumped to a radius of more than their own diameter will do well to pay some attention to their behavior and condition.

The making of hemispherical heads for steel vessels under pressure, such as boiler drums, is too elaborate a process, and requires too expensive apparatus to warrant the individual boiler maker attempting it upon his own account; but makers of such vessels would doubtless be glad to be able to buy such heads ready made, and it is not unthinkable that some properly equipped steel works might turn them out in standard sizes at an advantage.

⁂

Machinist Engineers

Some exception we feel should be taken to the views expressed in the letter on the above subject, on page 930. While a sure-enough, up-to-the-minute knowledge of the machinist trade is not essentially a part of the stock-in-trade of the engineer, it is certainly to his advantage to know something not only of that craft but of the composition of iron and the process of molding, and how a pattern should be made so that it will "draw" from the sand. A knowledge of forging and tempering steel is almost indispensable in all but the largest plants, and not amiss in any. Similarly, the "first aids" to boilers must be performed.

It is conceded that steam fitting is a part of the engineer's work, therefore why should he not have a knowledge of the proper use of the machinist's tools? In fact, the more fully the engineer is informed in the lines so closely connected to his own everyday duties, the more likely is he to emerge from the oiler class and stay at the head of his profession. The respect of those with whom he comes in contact is gained by his intimate knowledge of their occupation or lines, and not by trying to impress upon them the greatness of his own. This holds good from shop boys to directors. One must know the other fellow's game to win out with him.

Certain it is that in either case, doing or supervising, the more positive the accurate knowledge, the more satisfactory the results. What is more humiliating to an engineer than to be obliged to stand aside in his own domain while a machinist from an outside shop steps in and "does things" which may or may not be done according to the best practice. Surely, there are opportunities in abundance to become so informed on the ordinary operations of the machine shop as to enable the engineer to do satisfactorily all the machine work of the plant.

⁂

Cheap Firemen

When a boiler is under test, those responsible for its performance are very much alive to the merits and demerits of the fireman. They will pay a fireman who can get results ten dollars or more a day, and be glad to get him.

And after the test is over, they turn the boiler room over to a brawny Hunk at laborer's wages, put a mark on the steam gage and tell him to keep the pointer up to it.

The difference between good and poor performance on the test, the fulfilling of a guarantee, is a matter of a few hundred dollars—once and for all.

The Hunk can burn up this amount of money unnecessarily every month that the boiler is in commission.

Is it not as important to have expert intelligent work in the boiler room continually as during the brief interval of a test? Is not a continuous drain as desirable to avoid as a momentary loss?

F. W. Dean, M. E., told at a recent meeting of the American Society of Mechanical Engineers in Boston how an expert fireman saved the day in a boiler test which he was conducting by raising the evaporation per pound of combustible with the same boiler and furnace from 8.34 to 12.84 pounds. The difference in the cost of the coal which this one fireman would handle in a year and what the fireman whom he replaced would use to produce the same amount of steam at the rates given would amount to nearly five thousand dollars. Would it not be good business to make it worth his while to do it?

⁂

> Five men were badly burned, one probably fatally, yesterday when a water tender on the British steamer "Pectan" connected a steam-escape pipe with a boiler in which the men were working, and before the screams of the victims reached his ears, volumes of steam had entered the boiler.

Thus reads a recent press report. In an editorial in our issue of May 26, we made the statement that marine boilers seldom have nonreturn valves. This seems to have been one of them. Why in the name of all that is humane and reasonable is the slaughter and torture of help in the steamship boiler rooms allowed to continue, when means are at hand to prevent it?

The occasion is worthy the passing of an international law requiring all steam vessels to be equipped with this protection.

⁂

A coal scoop with an edge like a frayed lace curtain is a mighty poor tool in the boiler room. Trim the edge or get a new scoop.

Correspondence

What Was Wrong?

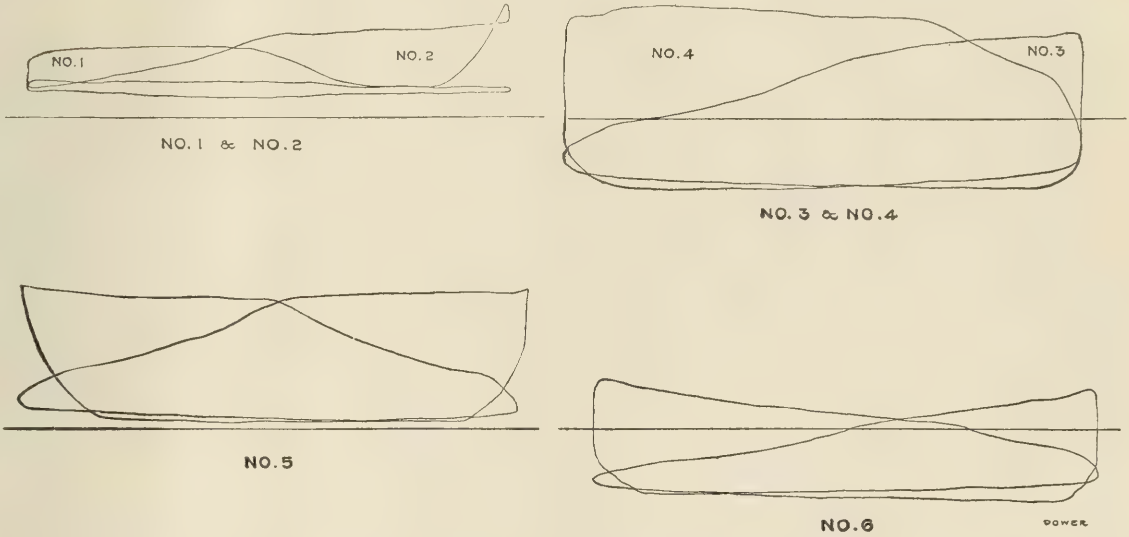


Fig. 1. Diagrams Showing Effect of Broken Cover Plate

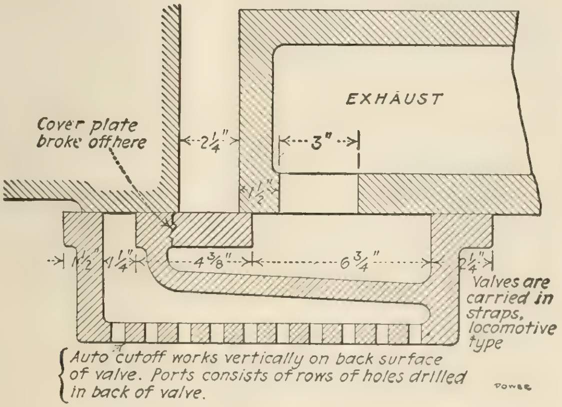

EXHAUST
Cover plate broke off here
2¼"
3"
1½"
1½"
1¼"
4⅜"
6¾"
2¼"
Valves are carried in straps, locomotive type
Auto cutoff works vertically on back surface of valve. Ports consists of rows of holes drilled in back of valve.
POWER

Fig. 2. Type of Valve

The diagrams, Fig. 1, were taken from the same engine, a compound-tandem with cylinders 15 and 26 by 48 in., running at 80 r.p.m., with a boiler pressure of 100 lb. per sq.in., about 200 deg. F. superheat and 25 in. of vacuum. No change in the valve setting was made between taking cards Nos. 1 to 4, and 5 and 6, the load being about equal on both occasions.

The high-pressure cylinder is fitted with its valves in two parts—i.e., one on each end of the cylinder—the quick cutoff valve being fitted to the back of the main valve and simply having a vertical movement, while the main valve has an unaltering travel. The low-pressure valve is the ordinary two-ported D-valve.

The trouble was caused by the lap plates at the back-end valve having broken off, as indicated in Fig. 2. The pieces were found in the low-pressure steam chest. The only remedy, of course, was a new valve.

E. Russell.

Rochdale, England.

A Steam Pump as an Air Compressor

The use of a steam pump as an emergency air compressor, which Mr. Hudson tells about in Power of May 19, page 715, is an interesting story, but it seems to have been a waste of more or less ingenuity. Two airtight tanks were used, and the steam pump would fill these alternately, the water compressing and expelling the air and driving it into the air receiver. It is not at all clear why the pump could not have been used to force the air directly into the receiver without all the paraphernalia of pipes, tanks, check valves, three-way valves, etc. Of course, either arrangement would waste a lot of power, but with that we have nothing to do, so long as the pump would actually work.

Now suppose that the quantity of water in the system was such that when one tank was entirely filled with water—as it should be, to expel all the air then compressed—and the other tank was entirely empty. Then if the pump kept on running it would simply pump air instead of water into the receiver; this might then be kept up indefinitely. It is likely this did occur at some time when the reversing of the three-way valves was delayed or forgotten.

This reminds me of a case of a boiler-feed pump that handled both air and water all the time. It was in the shop of George W. Richardson, the inventor of the pop-safety valve, nearly forty years ago.

The boiler was fed by a plunger pump (connected to the engine) of more than double the capacity required. The open end of the suction extended into a cup or small bowl, and into this bowl water fell steadily from a faucet. This flow regulated the boiler feed, and the faucet was often set so nicely as to require no change for half a day at a time. As the pump had a capacity considerably greater than the boiler requirements, it would at each stroke take up all the water then in the bowl and during the rest of the stroke it took in air, which went into the boiler with the water. Richardson used to say that the air facilitated the generation of steam and was good for the boiler generally, which may or may not be accepted at the present time.

FRANK RICHARDS.

New York City.

⁂

Sluggish Constant-Current Transformer

The accompanying sketch illustrates the connections of a 5.5-ampere, constant-current transformer applied to a series incandescent street-lighting circuit. The primary coil receives constant voltage and the secondary or movable coil maintains approximately constant current through the lamps in series with it. The movable coil weighs more than the counterweight and it tends to gravitate toward the stationary coil; unless both coils are energized it will come to rest at the bottom of its travel.

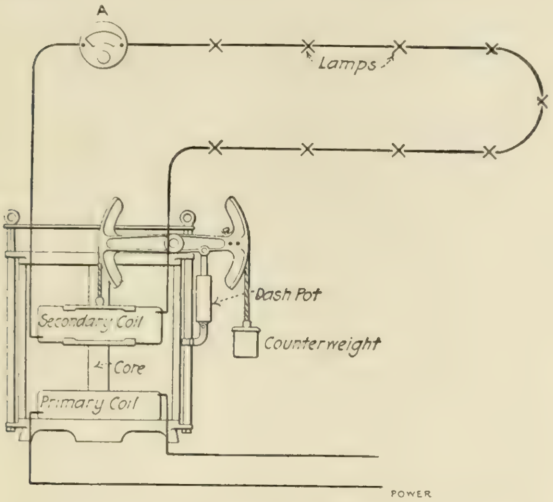


DIAGRAM OF ARC CIRCUIT AND CONSTANT-CURRENT TRANSFORMER

If the coils are energized, however, a repelling force exists between them and the position taken by the movable coil will depend upon the adjustment of the transformer, upon the voltage applied to the primary and upon the current in the secondary. Assuming the secondary current and primary voltage to be such that the movable coil is in a given position corresponding to the correct value of secondary current; if the secondary current or the primary voltage decreases, the repelling force between the coils becomes less and the excess weight of the movable coil will cause it to move downward until the secondary current is restored to its former value. If the secondary current increases or the primary voltage increases, either variation tends to increase the flux through the secondary, the resulting increase in the repelling force between the coils will overcome the excess weight of the movable coil and will cause it to move upward until the secondary current is restored to its adjustment value. An operator complained that a transformer was sluggish in action and that too much of a change in the primary voltage or in the secondary current was required to cause the movable coil to respond. The inspector found this to be true, and with the movable coil in any certain position if it were moved an inch in either direction, it would remain there, a corresponding change in the secondary current being maintained. He also noted that the movable coil was rubbing against the iron core, which caused friction, and upon leveling the transformer its action was much improved. The inspector then oiled the two rocker-arm bearings, removed the dashpot, poured out the old oil, flushed it with gasoline, renewed the oil and reinstalled the dashpot. After this cleaning the action was as good as could be expected on a machine that has ordinary sleeve bearings instead of knife-edges or ball bearings.

As in the case of a steam-engine governor, where a change in speed must take place before the governor can act, so in the case of a constant-current transformer—the secondary current must show temporary variations, because such variations are necessary to actuate the automatic feature of the device.

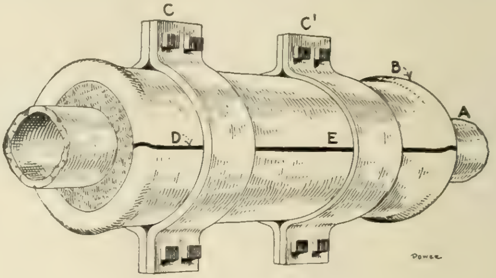
J. C. HORTON.

Schenectady, N. Y.

⁂

An Underground Pipe Repair

An 8-in., cast-iron water main under 70 lb. pressure leaked at several places. Numerous small holes within a distance of a few inches showed at each place, probably caused by the defective casting. The problem was how to make repairs without shutting off the water. Several factories, busy day and night, would have to close down if the water was shut off. A cast-iron pipe sleeve was split in two lengthwise, as shown at *D*, and center-punch marks were made at *E* to make sure of getting the sleeve together properly.



CAST-IRON PIPE CLAMP

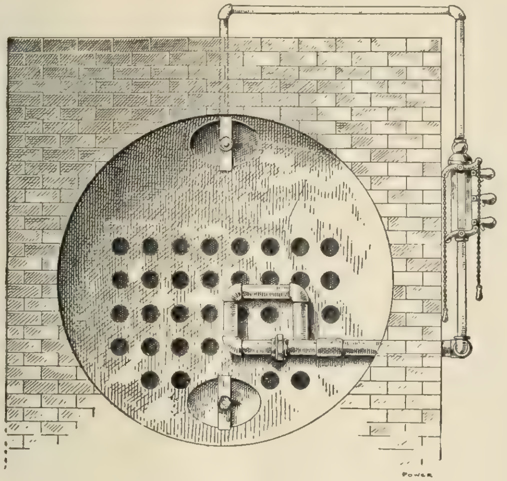
Two heavy clamps *C* and *C'* were used. Split sleeves were clamped over the defective places with strips of sheet packing ⅛ in. thick and ¾ in. wide between the two parts of the sleeve shown at *D*, shredded lead or lead wool was used and the sleeve calked up in the usual way. This is a job where the shredded lead shines, as a joint can be made up with water escaping at the start. These joints have been in use several years and have never given any trouble.

Toronto, Ont., Canada. JAMES E. NOBLE.

⁂

A Dangerous Water-Column Connection

The nipple in the boiler head which served as the lower connection to the water column showed distress. The horizontal pipe was so rigidly set in the brickwork that a new nipple could not be substituted and the pipe connected as before without considerable work and delay. The demand for the boiler was so urgent that a connection was made, as illustrated.



TEMPORARY CONNECTION

This, however, presented so much pipe surface to the action of the hot gases that the water level, as shown by the glass gage, was so erratic that the boiler had to be taken off the line again and a direct connection made. The capers of the water for the short time the boiler was on caused anxiety not soon to be forgotten.

Philadelphia, Penn. EDWARD T. BINNS.

⁂

Low Power Factor

An engineer who was in the habit of noticing things, observed that the switchboard output as recorded on the watt-hour meter corresponded closely with what he knew that his engines were doing; but he could not understand why his generators were overheating when the total recorded output was nowhere near their combined full-load ratings. He further determined that the total of his ammeter readings multiplied by the voltage and by any chosen number of hours, gave a result exceeding by 40 per cent. the absorption recorded by the watt-hour meter in the same length of time.

This engineer was more of an observer than a reader and while he had dug out all the data necessary to prove a case of low power factor, he was not in a position to associate his data with that name. Accordingly, he took his troubles to the chief, from whom he learned that the company had on order two synchronous condensers for improving the power factor.

Some contend that if a man is a good observer, good thinker and a good mechanic, he does not need books nor technical papers. A man with such an idea will fall as far behind progress in his line of work as he is far behind the times in his ideas. As a matter of fact, an observing, reasoning man will get more out of judicious reading of technical papers than any other kind of man will.

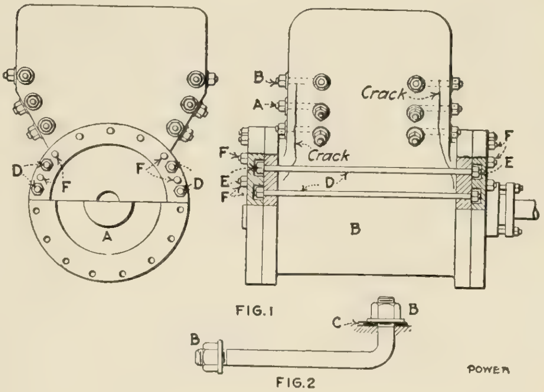
Schenectady, N. Y. J. C. HORTON.

⁂

Badly Cracked Cylinder Repaired

A large vacuum pump used for water circulating and having considerable suction lift, became airbound because of a leaky stuffing-box. The piston, racing through part of the stroke and then striking a body of water, caused four 15-in. cracks, two on each side of the cylinder. Practically, the pump was completely wrecked. As we could not replace it within a month, we did an all-night repair job; the pump lasted two years longer.

The manner of repair will be seen in Fig. 1. The bolts, one of which is shown in Fig. 2, were made of $\frac{7}{8}$-in. iron of suitable length. Holes were drilled in the pump casting and the bolts inserted from the inside, as in Fig. 1, the bolt *A* being in dotted lines. Each bolt was provided with a washer at each end, Figs. 1 and 2, under which a few turns of valve-stem packing *C*, Fig. 2, was placed to make the bolts water-tight. As the cracks extended down into the cylinder, the bolts *D*, Fig. 1, were also made of $\frac{7}{8}$-in. iron and put in place outside, the nuts being set up against the face of the flange to which the cylinder covers are bolted. To provide room for these nuts, the recesses *E* were made with a flat-point drill in the inner face of the cylinder covers. These recesses were so spaced as to come between the cover studs, shown at *F*, Fig. 1.



DETAILS OF REPAIR TO CRACKED CYLINDER

As the nuts on the bolts *D* were entirely surrounded by the packed joint of the cylinder covers, no packing was needed beneath them. Before setting up the bolts, some iron cement was stuffed into the cracks from the inside and outside; all the bolts were then drawn up and a water-tight job was had.

Kailua, Kona, Hawaii. H. K. SCHOLEFELD.

Hocking Valley Slack Coal

The chart given with the article by Morgan B. Smith in POWER, May 26, 1914, page 740, would be very misleading according to the way we find Hocking Valley slack. Take the Geological Survey of Ohio, Fourth Series, Bulletin No. 9, by Lord and Somermeier, page 291:

	Per Cent Ash	B.t.u. Bulletin	B.t.u. Chart
First test	15.41	10,600	11,600
Second test	16.28	11,100	12,000
Third test	9.94	12,000	12,800
Page 292.			
First test	8.79	12,200	13,000+
Average of nine tests	7.87	12,550	13,250
Page 295.			
Average of 65 tests	7.36	12,564	12,900

From our experience, and we burn about 300 tons of Hocking Valley slack per day, as well as these tests quoted, your chart gives on an average of 740 B.t.u. high and on many tests would indicate our coal as 1000 B.t.u. higher than it is.

E. R. ANDRIX.

Columbus, Ohio.

⁂

Leaky Cylinder Joint

In regard to J. Stewart's method of stopping a leaky joint on the front end of a cylinder, as described on page 603, Apr. 28, I think he could have managed it easier and made a more solid job had he drilled a hole in the frame at an angle so that it would strike the cylinder-face joint just outside of the stud-pitch line. This hole should be about half an inch gas size, tapped to a considerable depth, and then filled with a mixture of Smooth-On cement having the consistency of thick cream. Screwing in a plug would have forced the Smooth-On into the spaces where the leakage occurred.

On an engine of the size mentioned, it would probably have been necessary to drill several such holes, but the final results would have been better, and no unsightly clamps would have been seen on a new engine.

E. R. PEARCE.

Rochdale, England.

⁂

Machinist Engineers

An engineer applied for a position, and, although he had first-class references to show that he was a reliable man, with 20 years' practical experience in large and small plants, he was turned down because he was not a practical machinist. He even offered to work on trial on condition that he should receive no pay if he did not make good. He was told that a man who had not served his time as a machinist could not be a high-class engineer.

I do not agree with this statement. It is certain that many men who are handling our large steam plants successfully are men who have worked up from small plants, and they are able to maintain their positions by study and experience, and not through a knowledge of the machinist's trade. In reality, there is but little work around the average plant that requires a thorough knowledge of the machinist's trade.

Not many plants run a machine shop in connection with the plant, so even if an engineer were a machinist his skill would be of little use in the average power plant.

Hundreds of engineers can take an engine or other machine apart and reassemble it as accurately as could a machinist. A machinist might have a more direct way of doing certain work, he may know many ways of doing things not known to the engineer, but such work is not the engineer's chief occupation. If required to do this work frequently, he will soon acquire a skill equal to a machinist's. It is all right to be a machinist, but this trade is not necessary to become a high-class stationary engineer.

JOHN THORN.

Toronto, Ont., Can.

⁂

The Foot of the Ladder

The frontispiece in the issue of June 2 appeals strongly to me.

Some years ago, just after completing a technical course, I felt the need of supplementing my technical training with a course in commercial shop practice, and so I put in many hard hours building small engines, and, later on, working in a boiler room to learn the handling of a fire.

The experience that I gained in this way has been of great value, and I strongly recommend that all young college graduates from technical courses supplement their college training by experience gained in the boiler and engine rooms of power plants.

I have on my engineering staff at this time a young man but recently out of college, and he is now working as a fireman in a boiler room to gain the practical experience, which, in my opinion, is essential to a man who wishes to round out to full measure his knowledge of power-plant operation. I wish there were more like him, but unfortunately too many college men are content to lean over a drafting board and gain purely office experience rather than soil their hands at the work of a so called practical man.

The cartoons published in POWER each week are always interesting and instructive, and I hope they will furnish an inspiration to many men in the field in which POWER is preëminent.

GEORGE W. MARTIN,
Vice-President, The New York Service Co.
New York City.

⁂

One Cause of Flywheel Explosions

In a paper mill of 2000 hp., one of the engines was a cross-compound Corliss 16x32x42-in., operating at 100 r.p.m., having a single-arm flywheel 16 ft. in diameter. Passing this flywheel on one of my trips, I noticed that the rim was vibrating very rapidly. This vibration was not in step with the engine stroke as might be thought, but was actually a quiver, showing that the spokes were springing to the amount of about three-quarters of an inch. The last thing a paper-mill engineer does or thinks of is shutting down, so I tightened both main bearings to a snug running position, which stopped the vibration. I have no doubt that the flywheel would have been wrecked if I had not discovered it soon. I think that loose bearings are responsible for a great many flywheel explosions, especially on double engines..

E. P. SHIRES.

Leominster, Mass.

Inquiries of General Interest

Overtravel—What is meant by the overtravel of a valve?

J. M.

Overtravel occurs when a slide valve of an engine not only opens the port fully but travels by, and is the amount which the outside edge of the valve passes by the inside edge of the port.

Setting of Fusible Plug in Horizontal Return-Tubular Boiler—How should a fusible plug be set in a horizontal return-tubular boiler?

J. P.

A fusible plug should be set in the rear head and so placed that its center will be not less than 2 in. above the upper surface, of any of the tubes when the boiler is set, and the plug should project 1 in. inside of the boiler.

Coal per Horsepower-Hour—What is meant by "coal per horsepower hour"?

G. B.

The average number of horsepower developed during a stated period multiplied by the number of hours of that period would be the number of horsepower-hours, and dividing the number of pounds of coal required during the same period by the number of horsepower-hours would give the pounds of coal per horsepower-hour.

Operation of Throttling Governor—Does a throttling governor change the pressure of steam in the steam chest of an engine or does the steam-chest pressure remain the same?

A. T. A.

The office of a throttling governor is to admit only enough steam to the steam chest to keep the pressure up to that necessary to maintain the speed, and the steam delivered from the boiler to the governor is thereby reduced to a different pressure in the steam chest for each different load.

Sign Meaning "Greater" or "Less Than"—What is the meaning of the signs > or < when placed between two quantities?

C. B. H.

The sign > is to be read "is greater than" and the sign < is to be read "is less than"; for instance, $6 > 5$ is read "6 is greater than 5"; and $5 < 6$ is read "5 is less than 6," the opening of the angle always being placed toward the larger quantity.

Quality of Steam—What is meant by steam of 95 per cent. quality?

E. P.

The quality or dryness of steam is the portion or per cent. of its total weight which is in the form of vapor, as distinguished from that portion of the total weight which is in the form of moisture. Hence, when the quality or dryness is 95 per cent., that per cent. of its weight is in the form of vapor, and there is present $100 - 95 = 5$ per cent. of water, i.e., the wetness is 5 per cent.

Increase of Hydrant Discharge for Increase of Pressure—When the pressure in a water pipe line is maintained at 60 lb. per sq.in. at the pumping station, the pressure at a hydrant with the valve wide open is 16 lb. per sq.in. and the discharge is about 700 gal. per min. What hydrant pressure and rate of discharge would be obtained by raising the line pressure at the pumping station to 100 lb. per sq.in.?

K. W. A.

The loss of pressure from friction in the pipe line and also the pressure at the hydrant would vary, practically as the square of the velocity or rate of discharge, and as they would continue in the same proportion, then with a total pressure of 100 in place of 60 lb. per sq.in., the hydrant pressure would become $^{16}/_{60}$ of 100 or 26.66 lb. per sq.in. The velocity or rate of discharge would vary as the square root of the hydrant pressure, but as the hydrant pressure would vary as the total pressure and a discharge of 700 gal. per min. is obtained with a total pressure of 60 lb., then with 100 lb. total pressure the discharge would be

$$700 \times \sqrt{\frac{100}{60}} = 903 \text{ gal. per min. (approximately).}$$

Use of Radius Instead of Diameter in Boiler Formula—In figuring the strength of a boiler why is "radius times 2" used in the formula in place of "diameter"?

G. H. M.

Taking pressure and stress in pounds and all dimensions in inches, the complete expression for bursting pressure of the solid part of the sheet would be:

$$\frac{\text{Thickness of plate} \times \text{length of shell} \times \text{tensile strength per sq.in.} \times 2}{(\text{Radius} \times 2) \times \text{length of shell.}}$$

By canceling "length" and dividing the numerator and denominator by 2 the expression is reduced to the simpler form:

$$\frac{\text{Thickness} \times \text{tensile strength}}{\text{radius}},$$

or expressed algebraically,

the bursting pressure $p = \frac{t \times S}{r}$

Size of Line Wires—Six hundred 16-cp. lamps on a three-wire system are operated at a distance of ¼ mile from the station. If the allowable drop is 5 volts on each side of the system, what should be the size of the outside wires if the neutral is one-half the size of the outside wires?

A. W. C.

Assuming that the system is balanced, with 300 lamps on a side and each lamp taking ½ amp., the total load on each outside wire would be 150 amp. Counting both sides the total drop being 10 volts and length of the line 1320 ft., the problem may be solved by the formula:

$$A = 22 \times I \times L \div E,$$

and if

A = Area of conductor in circular mills;
I = Current in amperes;
L = Length of circuit, one way;
E = Total drop in volts.

Then,

$$A = 22 \times 150 \times 1320 \div 10 = 435{,}600.$$

A 400,000-circ. mil cable would probably answer for the outside wires and a 200,000-circ. mil cable for the inside wire.

Flow of Steam Through Orifice—What would be the increase in the flow of steam through an orifice into a vacuum of 14 in. over that taking place into a vacuum of 8 in., the pressure at the entrance side of the orifice in each case being 5 lb. per sq.in. gage pressure?

J. H.

The flow of steam of a greater pressure into an atmosphere of a less pressure increases as the difference of prssure is increased until the lower pressure becomes only 58 per cent. of the greater absolute pressure, but the flow is neither increased nor diminished with any greater reduction of the lower pressure. The pressure at the entrance side of the orifice being

$$5 + 14.7 = 19.7 \text{ lb. per sq.in. absolute,}$$

then when the orifice discharged into an atmosphere at 14 in. vacuum or

$$(30 - 14) \times 0.491 \quad 7.856 \text{ lb. per sq.in. absolute,}$$

the lower pressure would be

$$\frac{7.856}{19.7}$$

or about 40 per cent. of the higher; and discharging into 8 in. vacuum the lower would be

$$(30 - 8) \times 0.491 = 10.802 \text{ lb. absolute,}$$

or about 55 per cent. of the higher. Hence as in each instance the discharge would take place into an atmosphere of a less pressure than 58 per cent. of the absolute pressure on the entrance side of the orifice, there would be no increase in the amount of steam flowing into a 14-in. vacuum over that which would flow into an 8-in. vacuum.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XV

LAST LESSON'S ANSWERS

61. The force of friction will equal

$$200 \times 0.28 = 56\ lb.$$

which will be the force that will keep the casting moving at a uniform rate. The force required to move the casting will be greater depending upon the time it takes to get the casting in motion.

62. The force required to raise the body from the ground is greater than that necessary to move the body along the ground. The force of friction is the only force to be overcome in moving the body along the ground, while to lift the body the force of gravity (or the weight of the body) must be overcome. Generally the force of friction will be less than the weight of the body.

63. The coefficient of friction is equal to the tangent of the angle a which in this problem is 15 deg. Hence the value of f is

$$tan\ 15\ deg. = 0.268$$

64. The coefficient of friction

$$f = \frac{\text{the force of friction}}{\text{the total normal pressure}}$$

In this problem the friction is assumed as 600 lb. Therefore,

$$f = \frac{600}{60{,}000} = 0.01$$

65. The tangent of the angle a made by the plane will equal the coefficient of friction. Thus

$$f = tan\ a, \text{ hence } tan\ a = 0.3$$

From a table of tangents the value of a is found to be 16 deg. 40 min.

FRICTION (CONTINUED)

Friction is encountered in every type of machine or apparatus used in the power plant. The aim of the engineer is to reduce it to a minimum by using bearing metals and lubricants having a low coefficient of friction, combined with other equally important conditions. The introduction of ball and roller bearings has reduced this coefficient of friction from 0.04 for the ordinary steel journal running in a brass bearing, to 0.003 for the better forms of roller bearings.

The following laws of friction were stated by Morin and Coulomb as a result of a series of experiments.

I. *The friction depends on the nature of the surfaces in contact, but is independent of the area in contact.*

II. *The friction varies directly as the normal pressure, assuming the materials of the surfaces in contact to remain the same.*

III. *The friction is independent of the velocity when there is sliding motion.*

Recent experiments have proved that these laws are not absolutely true, more especially in the case of law III, where it has been found that the *friction decreases when the velocity increases.* Also, as stated in last week's lesson, the force of friction when a body is just about to move, is greater than when the body is in motion. The subject of friction will be discussed more fully under the lessons relating to work and efficiency.

This closes the work on Statics which has had to do with forces that produced a state of equilibrium of a given body. The following lessons will deal largely with *forces that do not produce equilibrium*, but which tend to produce motion of various kinds; and also with forces that perform work in a more or less efficient manner.

PART II—KINETICS

MOTION

A body is said to be in *motion relative to another when its position changes with respect to that of the other body*; or as sometimes defined, *motion* is *simply displacement* or *change of position.* At the outset it is well to note that, in the strictest sense of the word, all motion is *relative,* and the term *absolute motion* is apt to be misleading. Take for illustration a train passing a certain station at a definite rate of motion, say 30 miles per hour. It is not fair to say that the *absolute motion* of the train is 30 miles per hour, for while that is the motion of the train relative to the station, it is also true that the station has a definite velocity relative to the center of the earth which in turn has its velocity relative to some point in the universe. As another example, consider the motion of the crosshead of a locomotive. Here the crosshead has a motion relative to the frame of the engine, it has still another motion relative to the crankpin, a different motion relative to the track, and an entirely different motion relative to some fixed point in the universe. To avoid confusion it is best to compare the motions of various bodies to some point which for all practical purposes may be assumed as fixed. Thus to compare the motions of the crankpin and of the crosshead of the locomotive both might be referred to the frame of the engine. In the problems which are to follow the earth will be considered as the fixed point of reference.

As stated in Lesson VI, April 28, motion may be divided into two general classes: (1) *Translation* and (2) *Rotation.* In the case of translation all points of the given body will move in straight lines at the same rate of motion. In rotation, all points of the body will move in such a manner as to remain at a fixed distance from a given center of rotation.

Speed is the rate of motion of a body, or the rate at which the body describes its path. An automobile may be capable of developing a speed of 60 miles per hour and at the end of 2 hours be 120 miles from its starting point. The direction the machine went has nothing to do with its speed and hence the term speed involves only the two items of *magnitude* and *time,* without any reference being made to the *direction* of the motion. The speed of a body then is not sufficient to definitely fix the motion of the body.

Velocity is the rate of displacement of a body, and requires not only *magnitude* and *time* but also *direction.* The velocity of a body completely specifies the motion of the body, as to direction, magnitude and time. To say that a body has a velocity of 50 ft. per sec. means that if the body were to move for one second at a uniform rate it would pass over 50 ft. of space. The velocity might change before the completion of the second and therefore the velocity of a body indicates the speed or rate of displacement *for a given instant only,* without any prediction as to what may be expected the next instant. The velocity of the body may be uniform or variable; hence motion may again be classified as *uniform* or *variable* depending upon whether or not the body covers the same amount of space for every second it is in motion.

The common unit for space is the *foot,* the unit for time is the *second* and the unit for velocity is the number of *feet per second.* Unless otherwise stated, these units will be used in the formulas that follow in the succeeding lessons.

The velocity of a rotating point may be expressed in *linear units,* that is, feet per second, or in *angular measure,* that is, in *revolutions per minute,* or *radians per minute.*

Example—The distance from the center of the crankshaft to the center of the crankpin of a steam engine is 6 in. If at a given instant the engine is running at 300 r.p.m., what is the velocity of the crankpin?

Solution—This problem as stated is capable of two interpretations, depending upon what velocity is desired. It is evident that all points in the crank are making 300 r.p.m. Each time the engine makes one revolution the crank passes through 360 deg., or through 2π radians. (Note—*the angle at the center of a circle which intercepts an arc on the circumference equal to the length of the radius of the circle is called a radian.*) The circumference of a circle is $2\pi R$, where $\pi = 3.1416+$; hence there are $\frac{2\pi R}{R} = 2\pi$ radians in the circumference. Therefore a

$$radian = \frac{360\ deg.}{2\pi} = 57.3\ deg.\ (approx.)$$

Since the engine is making 300 r.p.m., the crank will pass through

$$300 \times 2\pi = 600\pi\ radians$$

This is known as the angular velocity of the crankpin. The second interpretation of the problem is to find the linear velocity of the crankpin, or the velocity with which the crankpin would move off in a straight line if, at any instant, the pin were suddenly released from the crank. The linear velocity will depend upon the distance of the pin from the center of the shaft. In one revolution the crankpin passes over a distance equal to the circumference of a circle whose radius is 6 in., and in one minute the crankpin moves over a distance equal to

$$\frac{2\pi \times 6 \times 300}{12} = 942\ ft.$$

Hence the linear velocity of the crankpin is 942 ft. per min., and the angular velocity is 600π radians per min.

The angular velocity of a body is equal to the linear velocity divided by the radius of rotation.

Let

R = The radius of rotation of the given body in feet;
N = Revolutions per minute (r.p.m.);
V = Linear velocity in ft. per min.;
a = Angular velocity in radians per min.

Then

$$V = 2\pi \times R \times N \tag{24}$$

and

$$a = 2\pi \times N \tag{25}$$

hence

$$\frac{a}{V} = \frac{2\pi \times N}{2\pi \times R \times N} \text{ or } a = \frac{V}{R} \tag{26}$$

The space S, traversed by a body moving with a uniform velocity of V ft. per sec. for a total time of T sec., is equal to $V \times T$ ft., or expressed as an equation

$$S = V \times T \tag{27}$$

STUDY QUESTIONS

66. At what crank angle is the friction between the crosshead and guide of an engine the greatest?

67. What kind of motion has the crosshead of an engine, (b) the crankpin, (c) a point on the rim of the flywheel.

68. The stroke of an engine is 18 in. If the engine makes 250 r.p.m., what is the average speed of the piston in ft. per min.?

69. Is the velocity of the crosshead of an engine uniform or variable? Should the velocity of the crankpin be uniform or variable? State reason for your answer.

70. A fireman walks at the rate of 4 miles per hour. How long will it take him to pass through a boiler room which is 250 ft. long, assuming that he walks in a straight line?

* * *

Salt Softens Clinker on Side-walls

Clinker adhering to the sides of the furnace walls and tending to bridge over the grate is an annoying trouble in many plants. Sometimes the clinker is knocked off with a firing tool, and in this way much damage is done to the brickwork.

In one Canadian plant serving a salt works, chain-grate stokers are used and considerable trouble was caused by clinker adhering to the side walls and extending out over the grate. The clinker was removed in the manner mentioned.

Much of the very low-grade salt is thrown away at these works. One day last winter the laborers conceived the idea of dumping some of the waste salt into the coal pile in front of the boilers instead of wheeling it a long distance in the cold. Soon after using this "salted coal" it was noticed that the clinker on the side walls had vanished; investigation and experiment showed that the salt was responsible for its disappearance. Now, when it is desired to remove clinker on the side walls a few shovelfuls of salt are thrown into the coal hopper feeding the stoker and a little is also thrown on the clinker.

* * *

New Anthracite Coal Field—An anthracite coal field has recently been discovered in the Province of British Columbia, Canada, within two miles of the G. T. P. Railway main line. Several seams have been located, one apparently 40 feet wide. An analysis of the outcroppings show: Carbon, 80.93 per cent.; volatile matter, 7.07 per cent.; moisture, 4.02 per cent.; ash, 7.98 per cent.; specific gravity, 1.661. The coal makes a strong and lasting fire, free from clinker. The development of this field will mean much to the Pacific Coast.

Boiler Explosions During 1913

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb	Size	Killed	Injured	Property Loss	Probable Cause
Jan 1	Portland, Me	E T Burrows Co					0	0		Furnace mouthpiece exploded
Jan 1	Dover, Del	Light & Water Plant					0	0		
Jan. 2	Waller, Penn	Thomas J Hess	7:00 p.m.	Traction engine	100	10 hp	1	0		Safety valve failed to act
Jan. 3	Lawrenceburg, Tenn	Lentz Sawmill	9:00 a.m	Locomotive		25 b hp	1	1	$100	Old and worn out
*Jan 4	Glen Allan, Miss.	Glen Allan Oil Mill		Water tube			0	1	$100	Low water
Jan 5	Marshalltown, Ia	Dr H C Mueller Residence		Heating			0	0	Small	
Jan. 6	Wheeling, W Va	Nebraska Masonic Home					0	1		
†Jan 6	Niagara Falls, N Y	Niagara Alkali Co.		Water tube	100	350 hp	0	1	$250	Blow-off opened and forgotten
Jan 7	Beaver Falls, Penn	Keystone Driller Co.	5:45 p.m.	Stub tubular upright	80	12 b hp	1	4	$100	Weakness of shell
Jan 7	Knoxville, Tenn	Tivy High School		Heating			0	0		
Jan 8	Cincinnati, Ohio	Victor Lamp Co.	4:45 p m	Tubular	85	300 b hp	0	1	$50	Blow-off valve failure
Jan 8	Coffeyville, Kan	Kansas Oil Refining Co.		Locomotive		25 hp	0	1	0	Fusible plug melted
Jan 8	Schenectady, N Y	American Locomotive Co					0	1		
Jan 9	Little Rock, Ark	Marion Hotel	8:45 a m	Water tube	100	150 b hp	0	0	0	Cast-iron header failed
†Jan 9	Toledo, Ohio	Office Building of Spitzer Bldg. Co.					0	1		
Jan 9	Salt Lake City, Utah	Salt Lake Tribune	1:30 p.m	Water tube	120	235 hp	0	0	$142 30	Low water
Jan. 9	Rochester, N Y	Payne's Garage	p.m.	Vertical tubular			0	3	$50	Failure of feed supply
Jan 9	Hephzibah, Ga	T E Smith's Sawmill	4:00 p m	Tubular		20 b hp	1	1	$300	Cold water injected into hot boiler
Jan 10	Brinkhaven, Ohio	Sawmill					1	0		
Jan 10	Valley City, N D	Electric Light & Water Works					0	0		
*Jan 10	Ensley, Ala.	Semet-Solvay Co		Water tube	125	250 b hp	0	0	$6	Defective material
*Jan. 10	Indiana Harbor, Ind.	Inland Steel Co.		Water tube			0	0		
*Jan. 10	Columbus, Ohio	State Institution for the Blind		Water tube			0	1		
Jan 10	South Boston, Mass	Hunt Spiller Mfg Corp.		Cast-iron sectional heating			0	0		
*Jan. 11	Richard City, Tenn	Dixie Portland Cement Co.		Water tube			0	1		
Jan. 11	Grasselli, Ind	Grasselli Chemical Co		Water tube			0	0		
*Jan. 11	Philadelphia, Penn.	John B Stetson Co.		Water tube			0	0		
Jan 11	Minneapolis, Minn.	North Side Greenhouse					0	1		
Jan. 12	Lebanon, Penn	Lebanon Valley Iron & Steel Co	10:00 a m	Horiz. tubular	70	125 b hp	0	5	$750	Low water
*Jan 12	Chicago, Ill	United States Brewing Co.		Water tube			1	0		
Jan 13	Burlington, Vt	City of Burlington		Cast-iron sectional	15		0	0	$317	
Jan 13	Pine Barren, Fla	McMillan Lumber Co.	5:30 p.m	Horiz. return tubular	100	72x16	1	4	$5000 approx	Low water
Jan 14	Vidalia, La	School		Heating			0	0		
Jan. 14	Toledo, Ohio	Buckeye Clay Pot Co					0	0		
Jan 15	New York, N Y	860 Westchester Ave					0	1		
Jan 15	New York City (Bronx)	Jos. Harper's Dry Goods Store		Heating			0	1		
Jan 16	Boonville, Miss	Lumber Camp Sawmill					1	4		
Jan 17	Leavenworth, Kan	Home-Riverside Mine					0	0		
Jan 17	Wooster, O	University of Wooster	7:00 a m.	Water tube	110	150 hp	0	0	$300 to $400	Low water, feed line stopped
Jan 18	Liberty Centre, Ohio	Moving Picture Theatre					0	0		
†Jan 18	Philadelphia, Penn.	Miller Lock Co.		Water-tube			0	0		
*Jan 18	Connellsville, Penn	Am Water Wks. & Guarantee Co		Water tube			0	1		
Jan 19	Plattsmouth, Neb.	Masonic Home	10:00 a.m.	Cast-iron heating	25	8 sections	0	1	$600	Defective casting
Jan. 20	Howland, Me	Howland Pulp & Paper Co.	8:30 a.m.	Return tubular	80	72″x19′ 6″	2	3	$40,000	Unknown
Jan. 21	Luzerne, N. Y.	Burt Shirt Co. Factory	6:30 p m.	Hot water			0	1	$25	Explosion of coal gas in flue
*Jan. 21	Willimantic, Conn.	Turner Silk Co.		Water tube	125	150 hp	0	0		Feed pipe failed Low water
*Jan. 23	Pittsburgh, Penn.	Carnegie Steel Co.		Water-tube			0	1		
*Jan 23	Pittsburgh, Pa.	Pittsburgh Term. Warehouse Co.		Water-tube	125		0	0	$80	
Jan 24	Macon, Ga	Atlanta Mng & Clay Co.		Horizontal-tubular	95		0	0	$150	
Jan 24	Bradford, Penn.	Newell Estate Oil Lease					0	1		
*Jan 25	Waukegan, Ill	American Steel & Wire Co.		Water tube			0	0		
†Jan. 28	Mitchell, Ind.	Lehigh Portland Cement Co	10:00 a.m	Water tube	150		0	0	slight	
Jan 28	Brandon, Vt.	Newton-Thompson Mfg. Co.		Horizontal-tubular			0	0	450	
Jan 29	Chattanooga, Tenn.	Y. M. C. A.		Cast-iron sectional	15		0	0	91	
Jan. 29	Indianapolis, Ind.	Alice Cathcart		Cast-iron sectional	15		0	0	$140	
Jan 29	Cleveland, Ohio	Upson Bolt & Nut Co.					0	4		
Jan. 30	Marshalltown, Ia.	Traction engine					1	0		
*Jan. 31	Troy, N Y.	Allen & Wheeler Co.					0	2		
*Jan. 31	Glen Allan, Miss	Glen Allan Oil Mills		Water tube	125		0	0	$150	Low water
†Feb. 1	Paris, Ill	T. A. Foley Sawmill					0	1		
Feb. 4	Worcester, Mass.	Elizabeth School		Cast-iron heating			0	0		
Feb. 4	Garden City, La.	Albert Hansen Lumber Co.		Tubular	150	72″x18′	0	0	0	Unknown
Feb 4	Bath, S. C.	Aiken Mfg Co. Cotton Mill					0	0		
Feb. 5	Portland, Ind.	Traction Engine					0	0		
Feb 5	Brookfield, Cook Co., Ill.	Lincoln & Maple Ave. School					0	0		
Feb. 5	Boston, Mass.	Pittsburg Plate Glass Co.		Cast-iron heating			0	0		
Feb. 5	Piedmont, Ala.	Sawmill	1:00 p.m.	Locomotive		25 b hp	1	1	$500	Low water
Feb. 6	Rusk, Tex.	Richey's Sawmill					2	5	Considerable	
†Feb. 6	Buhl, Minn.	Fort Henry Mining Co.	11:30 a.m.	Return-tubular	150	72″x18′	0	0	$96 25	
*Feb. 6	Chicago, Ill.	Congress Hotel		Water-tube			0	0		
Feb. 6	New York City	Isaac Guggenheim		Horizontal-tubular	80		0	0	$50	
Feb 7	San Francisco	Consumers Ice Co.		Water-tube			0	0	$600	
*Feb 7	New Orleans, La.	New Orleans Ry & Lt. Co.		Water-tube			0	0		
*Feb 7	Waterbury, Conn	Scoville Mfg. Co.	10:00 a.m.	Water-tube	125	400 hp.	0	1	Tube	
Feb. 8	Louisville, Ky	C A. Roberts		Cast-iron sectional	15		0	0	$125	

*Tube failure. †Blowoff failure.

BOILER EXPLOSIONS DURING 1913—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	In-jured	Property Loss	Probable Cause
Feb. 8	East Providence, R. I.	245 Broad St.					0	0		
†Feb. 9	Williamsburg, Penn.	West Virginia Pulp & Paper Co					0	0		
Feb. 9	Hale, Mich.	Salisbury Shingle Mill		Upright-tubular	95		0	32	$500	
Feb 10	Baltimore, Md.	Apt'm't House, 2117 Guilford Av	10:20 a.m.	Cast iron, steam, vapor		450 sq.ft.	0	0	Exp. $15	Unknown
Feb. 11	Fort Kennedy, Penn.	Ehret Magnesia Covering Co.		Water-tube			0	0	Fire $450	
Feb 12	Menominee, Mich	White Cedar Mill					0	2	$500	
*Feb 12	Columbia, S C	Columbia Ry., Gas & Electric Co.		Water-tube			0	0		
Feb. 12	West New York, N J	Trinity Reformed Church		Cast-iron heating			0	0		
Feb 12	Chippewa Falls, Wis	Star Mills	8:00 a.m.	Firebox	Low	10 b.hp.	0	0	slight	Old worn out boiler. Staybolts pulled out
Feb. 13	Beechurst, L. I	27th St. and 16th Av.					0	1		
Feb 13	East Orange, N. J	Edison Works					0	0		
*Feb. 13	Pittsburgh, Penn	Allegheny Co Light Co		Water-tube			0	2		
Feb 13	Portland, Me	Maine Central R. R Co Wharf					0	0		
†Feb 13	Philadelphia, Penn	Protestant Episcopal Hospital					0	0		
†Feb. 14	Philadelphia, Penn	Protestant Episcopal Hospital					0	0		
Feb. 14	Boston, Mass	Snow Association, 105 Federal St		Cast-iron heating			0	0		
Feb 14	New York	Mark Schwartz		Cast-iron sectional	15		0	0	$150	
Feb 15	St Louis, Mo	Paul Ellenberg		Cast-iron sectional	15		0	0	$90	
*Feb 15	South Bend, Ind	Studebaker Co., Carriage Works		Water-tube			0	0		
Feb 15	Provo, S D	Locomotive					3	0		
Feb 15	Wallisville, Mass	C R. Cummings Sawmill					4	5	$10,000	
Feb 15	Newburg, Ind	Sargent Coal Co.					0	0		
*Feb 16	New Orleans, La	Crescent City Stock Yards		Water-tube			0	0		
*Feb 17	New Orleans, La	New Orleans Ry. & Light Co		Water-tube			0	0		
Feb 17	New York City	Mrs. Anna Quinn		Cast-iron sectional	15		0	0	$72	
Mar 18	New York, N. Y	Apartment House, 113 Leonard St.		Cast-iron heating			0	0		
Mar 18	Baywood, Fla	Stafford Sawmill					1	1	$1500	
Feb 19	Smithers, W. Va	W R Johnson Coal Co		Horizontal-tubular	100		0	0	$1100	
Feb 19	Oil City, Penn	Carnick Junk Co					0	1		
Feb. 19	Wichita, Kan	Bridge Pasteurized Milk Co.		Locomotive type			0	0		Crown sheet collapsed
Feb. 19	Holyoke, Mass	Annie Shafer's Apartment House		Heating			0	0		
Feb 19	Camden, Ark	Cleveland School		Cast-iron heating			0	0		
Feb 21	Denver, Colo	Jupiter Coal Co					0	0		
Feb 21	Unity, Penn	South Penn. Oil Lease					0	1		
*Feb 22	Toledo, Ohio	Pickand Mather Co. Blast Furnace		Water-tube			0	0		
*Feb 22	Piermont, N Y	Piermont Paper Co.		Water-tube			0	2		
Feb 23	Louisville, Ky	Monon. River Coal & Coke Co.		Horizontal-tubular	80		0	1		
Feb 24	Brush, Col	Brush Light & Power Co.					0	0		
Feb 25	Providence, R I.	H. C. Clarke Estate Coal Dealers					0	0		
*Feb 25	Crystal City, Mo.	Pittsburg Plate Glass Co		Vertical tubular			0	3		
Feb. 25	Iron River, Mich.	Munro Iron Mining Co.					0	0	small	
*Feb 28	Youngstown, Ohio	Mahoning & Shenango Ry. Lt. Co		Water-tube			0	1		
Feb 28	Philadelphia, Penn.	Nathan Somers Hat Works		Hot-water heating			0	1		
*Mar 1	Waukegan, Ill	American Steel & Wire Co.		Water-tube			0	0		
*Mar 1	Handley, Texas	Northern Texas Traction Co.		Water-tube			0	0		
Mar 2	Honesdale, Penn.	Riefler & Sons Wood Alcohol Plant					0	1		
Mar 3	Nyack, N. Y	Robert Smith Confectionery Co.	9:00 a.m.	Hot-water heating	20	800 sq.ft.	0	0	$125	Frozen overflow pipe from expansion tank
Mar. 3	Alton, Ill	Western, Cartridge Co					0	0		
Mar 3	Chattanooga, Tenn	Atlantic Ice & Coal Corp.		Water-tube			0	1		
Mar 3	Gladwater, Tex	Gladwater Lumber Sawmill	9:17 a.m.	Horizontal tubular		60″x14′	3	2	$1500	Low water and high pressure
Mar 4	Indiana Harbor	American Steel Foundries		Water-tube			0	0	$1000	
Mar 4	Milwaukee, Wis	Milwaukee Lithographing Co	1:00 p m		60		0	1	nominal	Blowoff pipe broke off
Mar 4	Grand Rapids, Mich	Voight Milling Co		Water-tube			0	0		
Mar 4	Cedar Rapids, Iowa	J S Polland's greenhouse					0	0		
†Mar 5	Omaha, Neb	Omaha General Hospital					0	0		
*Mar 5	Laurel Hill, L I, N Y	Nichols Copper Co.	7:30 p.m.	Water-tube	160	240 b.hp.	0	1	trifling	Defective tube
*Mar 5	St Louis, Mo	Am Car & Foundry Co.		Water-tube			0	3		
Mar 5	McAdoo, Penn	Greek Catholic Rectory					0	0		
*Mar 6	Buffalo N Y	International Ry Co		Water-tube			0	0	$75	
Mar 6	El Dorado, Ark	El Dorado Light & Water Co		Water-tube			0	0		
*Mar 6	Etna Boro, Penn	Carnegie St Co 's Isabella Furnace		Water-tube			0	0		
Mar 7	Sharon, Penn	Wilke's Rolling Mill	5:00 a.m.	Vertical water-tube	80	75 b.hp.	3	3	$15,000	Admitting cold water after low water
Mar 8	Philadelphia, Penn	J. S Brill Co. Car Shop		Water-tube			0	1		
Mar 10	Fordyce, Ark	Foedyce Lumber Co.		Locomotive			0	0		
Mar 11	Vincennes, Ind	Meyer Bros Sawmill	12:00 m.	Traction engine		20 b.hp.	1	3	$800	Unknown
*Mar 11	Pittsburgh, Pa	Crucible Steel Co. of America		Water-tube			0	0	$350	
Mar 12	Glen Wilton, Va	Princess Furnace Co.					0	0		
*Mar 13	Cambridge, Ohio	Am Sheet & Tin Plate Co.		Water-tube			0	0		
*Mar 15	Colorado Springs, Colo	United Gas & Elec. Corp.	7:00 a.m.	Water-tube	150	500 b.hp.	0	0	$175	Defective tube
Mar 16	San Benito, Tex	San Benito Land & Water Co.		Horizontal-tubular			1	0	$100	
Mar 16	Plainville, Kan	Plainville Mill & Elev. Co.	4:00 a.m.	Water-tube			0	1	0	Gas exploded underboiler. Oil used
Mar 16	Atlanta, Ga	Imperial Hotel	11:00 a.m.	Cast-iron heating	12	15 sq.ft. grate	0	0	$100	Casting cracked
Mar 16	Florence, Neb.	Price Building	4:00 p.m.	Cast-iron heating	5-12		0	0	$500	Boiler run dry
Mar 17	Owensboro, Ky	B C Wilson's Sawmill					2	2		
†Mar 18	Cedar Rapids, Iowa	Hotel Montrose		Return-tubular	85		0	2	slight	Stripped thread
Mar 20	Philadelphia, Penn	Standard Roller Bearing Co.		Water-tube			0	0		Cast-iron cross box failure
Mar 21	Norristown, Penn	American Equipment Co.	5:30 a.m.	Locomotive type	100	80 b.hp.	0	1	0	Low water

*Tube failure †Blowoff failure.

BOILER EXPLOSIONS DURING 1913—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Mar 22	Normal, Ill.	Christian Church		Heating			0	0	slight	
Mar 24	Chicago, Ill.	Armour & Co. Stock Yards		Water-tube			0	0		
*Mar 24	Ashaway, R. I.	Ashaway Line & Twine Co.	5:30 a.m.	Water-tube	80		0	0	$50	
Mar 24	Ecorse, Mich.	Worcester Salt Co.					0	0		
Mar. 24	Milwaukee, Wis.	Thomas Furnace Co.	p.m.				0	2		
*Mar 25	Tonawanda, N. Y.	Tonawanda Board & Paper Co.		Water-tube			0	0		
Mar. 27	Salt Lake City, Utah	Irving School	7:30 a.m.	Cast-iron heating	15	S36—5	0	0	$200	Low water
†Mar. 27	Yolande, Ala.	Yolande Coal & Coke Co.					0	1		
Mar. 29	Vinita, Okla.	Middle West Utilities Co.					0	0		
Mar. 31	Toronto, Ont.	King Suspender Co.	p.m.	Cast-iron hot water			0	0	$100	Unknown
†Apr. 1	Aberdeen, S. D.	Tiffany Bros. Laundry		Tubular	100	72″x18′	0	0	$150	
Apr. 2	Houma, La.	St. Louis Cypress Co. Dredgeboat	a.m.				0	2		
*Apr. 2	Wampenn, Penn.	Crescent Portland Cement Co.	4:15 p.m.	Water-tube	150	500 hp	0	2	small	
†Apr. 5	Bridgeport, Conn.	Spring Perch Co.					0	0	$25	
Apr. 6	Prospect Hill, Mo.	Union Sand & Material Co.		Horizontal-tube			0	1		
*Apr. 8	Pittsburgh, Penn.	Duquesne Light Co.		Water-tube			0	1		
Apr 9	Martins Creek, Penn.	Alpha Portland Cement Co.		Water-tube			0	0		
Apr 10	Rose Lake, Idaho	Rose Lake Lumber Co.					0	0		
Apr 10	Philadelphia, Penn.	100 Phili-Ellena St.					0	1		
Apr 10	Bartelsville, Okla.	Barnsdall Oil Co.		Well drilling outfit			0	1		
Apr 10	Butler, Penn.	Tugboat					2	0		
*Apr 10	New Orleans, La.	Crescent City Stock Yard		Water-tube			0	0		
Apr. 13	Cherry Grove, Ore.	Lovegren Lumber Co.					0	0		
Apr. 14	Sebewaing, Mich.	C. F. Bach Brewery					0	0		
*Apr. 15	Indianapolis, Ind.	Terre Haute & Eastern Trac. Co.		Water-tube			0	0		
†Apr. 16	Fort Smith, Ark.	Border City Cold Storage Co.	4:00 a.m.	Horizontal tubular	120	72″x18′	0	0	$5 00	
*Apr. 17	Seattle, Wash.	Washington Hotel Co.		Water-tube			0	0		
Apr 19	Venice, Penn.	Venture Oil Co. Oil-well Drilling	7:00 p m.	Oil well drilling outfit			2	2		Low water
Apr. 20	Selma, Calif.	Frank Rouch's Pumping Plant	10:00 a.m.	Traction engine	70	30 hp.	1	1	$500	Old boiler
Apr 21	Tuna, Penn.	Oil well drilling	5:00 p m.				0	1		
*Apr. 22	Charleston, S. C.	Charleston Ry., Lt. & Power Co.		Water-tube			0	0		
Apr. 22	Mt. Pleasant, Mich.	Thompson & Son Brickyard	10:30 a.m.	Horizontal tubular		50″x16′	4	4		Low water and old defective, patched boiler
Apr. 23	Columbia, Penn.	Frankford's Sawmill	1:20 p.m.	Horizontal tubular	175	20 b.hp.	0	2	$2000	Boiler worn out
Apr 26	Hibbing, Mich.	Oliver Iron Mining Co.					0	0		
Apr 28	Atlanta, Ga.	Imperial Hotel		Cast-iron heating			0	0		
*Apr. 28	Trenton, N. J.	American Bridge Co.		Water-tube			0	0		
Apr 30	Lyman, Miss.	Ingraham-Day Lumber Co.		Locomotive			1	0		
Apr. 30	Louisville, Ky.	Sixth St. School		Cast-iron heating			0	0		This and the following were two separate accidents
Apr 30	Louisville, Ky.	Sixth St. School		Cast-iron heating			0	0		
Apr 30	Danville, Ky.	George Rowsey Sawmill					0	2		
May 1	Longview, Tex.	Castleberry & Flewellyn's Planer	4:00 p.m.	Return tubular		48″x16′	0	2	$3500	Deteriorated shell was very old and thin
May 2	Liberty, Mo.	Liberty Elec. Lt. & Pr. Co.					0	0		
*May 3	Kalamazoo, Mich.	King Paper Co.		Water-tube			0	0		
May 3	Pine Creek, Va.	Guthrie Sawmill	11:00 a.m.	Tubular			2	1	$400	Low water
May 4	New Salem, Penn.	Herbert Coke Works					0	2		Low water
May 5	Union Bridge, Md.	Tidewater Cement Co.		Water-tube	125		0	1		
*May 5	Kalamazoo, Mich.	City Lighting Plant	2:00 a.m.	Water-tube	140	175 hp.	0	1	$75	Defective tube
May 5	St. Johnsbury, Vt.	North Monroe Sawmill	11:00 a.m.			30 hp.	0	0	$1000	Low water
May 6	Monroe, N. H.	North Monroe Steam Mill Co.					0	1		
May 7	Point Breeze, Penn.	United Gas Improvement Co.					0	2		
May 8	Saratoga Springs, N. Y.	Alva Seybolt's Apartment House	6:30 a.m.	Cast-iron heating			0	0		Not known
May 8	Oil City, Ky.	Price & Kinslow Sawmill		Locomotive type	120	25 hp	0	3	$300	High pressure
May 9	Fort Wayne, Ind.	Traction plant	2:00 a.m.	Water heater	175		1	1	$1500	Release valve inoperative
May 10	New Orleans, La.	French Market Ice Co.		Water-tube	100		0	1	60	
May 10	Winder, Ga.	Chas. R. Haskin's Ice Plant	7:30	Tubular	100	60″x13′	0	0	$75	Flues thin, failed
May 10	Lebanon, Ky.	Thomas Mattlingly's mill					0	1		
*May 10	Alabama City, Ala.	Standard Steel Co.		Water-tube	150	375 hp.	0	0	none	
*May 11	Alabama City, Ala.	Standard Steel Co.		Water-tube	150	375 hp.	0	0	none	(One also day before)
May 14	Humble, Tex.	Cash Oil Co. Pumping Plant					1	0		
May 14	Omaha, Neb.	Orkin's Store	9:00 a.m.	Water-tube		150 b.hp.	1	1	$100	Tube failure
May 14	Sandusky, Ohio	Sandusky Gas & Elec. Co.		Water-tube			0	0		
May 15	New Orleans, La	Empire Rice Milling		Horizontal-tubular	100		0	1	$350	
May 15	Toronto, Ont., Can.	Restaurant					0	2		
May 15	Boston, Mass.	Boston Protective Co., Purchase St.		Hot-water heating			0	0		
May 17	Paducah, Ky.	West Kentucky Coal Co.	3:00 a.m.	Firebox	125	48″ shell	2	1	$5000	Low water
*May 19	Flint, Mich.	General Motors Co.	9:00 p.m.	Water-tube vertical	120	5′x24′ 4″	0	0	$45	
*May 19	Bordentown, N. J.	Public Service Corporation		Water-tube			0	0		
May 19	Lumbertown, N. J.	Blacksmith Shop					0	3		
May 19	Union Bridge, Md.	Republic Finance Co.		Water-tube			0	1		
May 20	Kentwood, Ga.	Brooks-Scanlon Co. Planing Mill					0	0		
*May 20	Philadelphia, Penn.	Philadelphia Rapid Transit Co.		Water-tube			0	0		
May 22	Roanoke, La.	Zwick Plantation	6:00 a.m.	Tubular	60-80	100 b.hp.	0	0	$1000	Valve stopped and attendant asleep
*May 24	Waukegan, Ill.	Am. Steel & Wire Co.		Water-tube			0	0		
May 24	Rockland, Me.	W. H. Glover Co.	10:00 a.m.	Horizontal	70	65 hp.	0	0	Boiler only	
May 26	Knoxville, Tenn.	J. A. Smith		Water-tube	100		0	0	$120	
May 26	Pittsburgh, Pa.	H. J. Heinz Co.		Water-tube	125		0	0	$250	
*May 29	Minneapolis, Minn.	Minneapolis Malt & Grain Co.		Water-tube Lyons	150	78″x18′	0	0	$10.50	Oil
May 31	Lima, Ohio	Ohio Electric Railway Co.		Water-tube			0	0		

*Tube failure. †Blowoff failure.

BOILER EXPLOSIONS DURING 1913—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
June 1	Jennings, La.	E. Houssiere Farm					1	1		
June 3	Long Island City, L. I., N. Y.	Brooklyn Range & Boiler Co.					0	1		
June 3	Leonard, Tex.	Leonard Ice & Coal Co.					0	0		
*June 6	Berlin, Conn.	Berlin Brick Co.					0	0		
*June 6	Burlington, N. C.	Elmira Cotton Mills Co.		Water-tube			0	0		
*June 6	Trenton, N. J.	Public Service Corp.	4:00 p.m.	Water-tube	150	300 b.hp.	0	1	0	Unknown
†June 7	Lancaster, Tex.	Lancaster Milling Co.					0	0		
June 7	Akron, Ohio	Thos. Phillips Co., Paper Mill	9:00 a.m.	Vertical tubular	85	5′x12′	0	1	small	Defective flue; boiler old and in bad condition
June 9	Dunmore, Penn.	Erie R.R. Shops	10:45 a.m.	Water-tube		150 b.hp.	1	2		Cap burst by tigntening under pressure
*June 10	Nadine Sta., Pittsburgh, Penn.	Penn. Water Co., Wildwood	10:00 p.m.	Water-tube			0	1	trifling	
*June 10	Bogalusa, La.	Great Southern Lumber Co.		Water-tube			0	0		
June 12	Manhattan, Kans.	Manhattan Ice, Light & Power Co.	2:00 a.m.	Return tubular	120	150 hp.	0	0		Bag in firesheet. No escape of steam
June 13	Glenn Wilton, Va.	Princess Furnace Co.		Water-tube			0	0		
June 14	Logansport, Ind.	Northern Hospital for the Insane	3:00 p.m.	Water-tube	80	264 b.hp.	0	0	0	Tube stopped causing header to crack
June 16	Stevens Creek, Ga.	J. G. White Construction Co.		Locomotive			0	0		
June 16	Philadelphia, Penn.	Miller Lock Co.		Water-tube			0	0		
*June 16	Kalamazoo, Mich.	King Paper Co.		Water-tube	150	300 b.hp.	1	0	0	
*June 16	Mackinac Island, Mich.	Municipal Water, & Light Co.		Mt. Vernon	150	60″x18′	0	0	$15	
June 16	Akron, N. Y.	Frank Owen	10:00 a,m,	Locomotive type		12 b.hp.	0	0	0	Rusting off of staybolts above crown sheet
June 19	New York, N. Y.	Beth Israel Hospital	4:00 a.m.	Water-tube		80 b.hp.	0	2	$25	Defective tube
June 20	Burlington, Iowa	Burlington Sanitary Milk Co.	6:00 p.m.	Horizontal tubular	100	44″x14′	0	0	repairing	Coming down of scale caused bag
*June 20	Youngstown, Ohio	Brier Hill Steel Co.		Water-tube			0	0		
*June 20	Alabama City, Ala.	Standard Steel Co.					0	0		
*June 20	Louisville, Ky.	Rugby Distillery Co.	10:00 a.m.	Water-tube	125	300 b.hp.	0	3	$500	Unknown
June 20	Somersworth, N. H.	Great Falls Mfg. Co. Cotton Mill					0	0		
*June 21	Jonesville, Mich.	Omega Portland Cement Co.	10:00 a.m.	Water-tube	150	250 hp.	0	0	$300	
June 22	Kalamazoo, Mich.	Paper Mills					1	0		
June 23	Nyack, N. Y.	Lyons Dye Works					0	1		
June 23	Pittsburgh, Penn.	Union Ice Co. Factory No. 2		Water-tube			0	0		
June 24	Louisville, Ky.	Good Luck Polish Co.	5:00 p.m.	Upright	40	3 b.hp.	0	0	boiler only	
June 26	Little Rock, Ark.	Bolz-McBride Cooperage Co.		Horizontal-tubular	100		0	0	$600	
*June 28	Newark, N. J.	Public Service Corporation		Water-tube			0	0		
June 29	Brush, Calif.	Chris. N. Elling Ice & Brick Plant		Tubular	100	40 hp.	0	0	0	Erupted, no explosion
June 30	Chicago, Ill	C. L. Willey, Lumber Mill		Water-tube			0	0		
*July 2	Brakenridge, Penn.	Allegheny Steel Co.		Water-tube			0	0		
July 2	Conasanga, Tenn.	Alacuky Lumber Co.					0	0		
July 2	Alexandre Bay, Newfoundland	Alexandre Bay Lumbering Co.					5	1		
July 6	Montezuma, Ind	Marion Brick Works					0	0		
July 7	East Brambleton, Va.	Millner's Dairy					0	1		
July 7	Portage, Penn.	Sonman Shaft					0	0	small	
July 7	Belleville, Ill.	St. Clair County Gas & Elec. Co.					0	1		
July 8	Rockport, Ill.	National Lock Co.	6:00 a.m.	Water-tube	40	250 hp.	0	0	$600	Low water
July 8	Alva, Okla.	Fisher Farm	8:00 a.m.	Return tubular		44″x8′	1	1	$2000	Ignorance, weak material, old age, high pressure
July 10	Brewton, Ala.	T. R. Mills Co.		Locomotive	120		0	0	$400	
*July 10	New Orleans, La.	Central Ice & Cold Storage Co.		Water-tube			0	0	small	
July 11	Norborne, Mo., Carroll Co.	Evan's Farm					1	0		
†July 11	Charlton City, Mass.	Aldrich Mfg. Co., Satinet Mill.		Horizontal-tubular	125	72″	1	0	$500	Careless fitting
*July 11	Minneapolis, Minn.	Minneapolis Malt & Grain Co.		Water-tube			0	0		
*July 12	Alabama City, Ala.	Standard Steel Co.		Water-tube			0	0		
July 13	Pittsburgh, Penn.	Union Ice Co., Factory No. 2		Water-tube			0	0		
July 13	Maricopa, Calif.	National Pacific Oil Co.					0	1		
July 14	Rockford, Ill	W. F. & John Barnes Co.					0	0		
July 15	Petaluma, Calif.	City Road Work					0	1		
July 15	Superior, Neb.	John Radke Threshing Outfit					0	0		
July 16	Indianapolis, Ind.	Polar Ice. Co.	10:00 a.m.	Tubular	80	66″x16′	0	0	0	Unknown, bagged
July 16	Sandusky, Ohio	Sandusky Gas & Elec. Co.		Water-tube			0	0		
July 17	Clinton, Iowa	Swift & Co.	p.m.	Return-tubular	90	60″x16′	0	0	$4500	Dirty boilers
July 17	Rockdale, Tex.	Vogel Lignite Mine					0	3		
July 18	Trinity, Ala.	Grist and Saw Mill					2	3		
*July 18	Wichita, Kans.	Jacob Dold Packing Co.		Water-tube			0	0		
July 19	Decatur, Ala	Grist and Saw Mill					2	3		
July 19	Harrison, Ohio	Joseph Kraus Farm	p.m.	Threshing machine	140		0	2	small	Weak place in front of boiler
†July 20	Cleveland, Ohio	Lake City Ice Co.					0	0		
July 21	Trenton, N. J.	Trenton Street Railway Co.		Water-tube			0	0		
July 21	Kalamazoo, Mich.	King Paper Co.					1	0		
July 22	Aguilar, Colo.	National Fuel Co.					0	0		
July 22	Bedford, Ky.	R. L. Conn Traction Engine	7:00 a.m.	Threshing machine	125	16 hp.	0	2	$600	Thin sheet
*July 23	Scranton, Penn.	Am. Gas & Electric Co.		Water-tube			0	0		
*July 24	Blue Island, Ill.	Public Service Corp.		Water-tube			0	0		
July 25	Waukegan, Ill	Fould's Mill					0	1		
July 25	Windy Point, Del.	Sawmill					1	0		
July 25	Latrobe, Penn.	Railway Steel Spring Co.		Water-tube			0	0		
July 25	Oxnard, Calif.	American Beet Sugar Co.		Water-tube			1	1	small	
July 25	Camden, N. J	McAndrews & Forbes Co. Factory		Water-tube			0	0		
July 25	Montreal, Que., Can.	Canadian Car & Foundries Co.	a.m.	Water-tube		350 b.hp.	3	0		
July 30	Columbus, Ohio	U. S. Cast-Iron Pipe & Foundry Co.					0	0		
July 30	Dixon, Ill.	Y. M. C. A. Building		Water-heating			0	0		
July 31	Cypress, Ala	Southern Cooperage Company		Horizontal-tubular	90		0	0	$300	

*Tube failure. †Blowoff failure.

BOILER EXPLOSIONS DURING 1913—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	In-jured	Property Loss	Probable Cause
*July 31	Hamilton, Ohio	Hamilton Otto Coke Co.		Water-tube			0	0		
July 31	Tiffin, Ohio	Sun Oil Co.					0	1		
July 31	Grand Mound, Wash.	Briscoe & Co. Logging Camp	2:00 p.m.	Vertical tubular	80		1	0	none	Unknown
*Aug. 1	East St. Louis, Ill.	Swift & Co.		Water-tube			0	2		
*Aug. 2	Helena, Ark.	Helena Gas & Electric Co.		Water-tube			0	0		
Aug. 2	Mason City, Iowa	Farm	2:00 p.m.	Traction engine	120	16 hp.	1	1		Deterioration
Aug. 5	Iowa City, Iowa	Threshing Machine					0	2		
Aug. 6	Philadelphia, Pa.	H. Vaughan		Vertical-tubular	90		0	0	$700	
†Aug. 6	Chaska, Minn.	C. H. Klein Brick Co.	11:30 a.m.		95	66"x16'	0	1		
Aug. 6	New York, N. Y.	Department Store, J. McCreery Co.					1	2		Cast-iron tee ruptured (steam pipe)
*Aug. 6	Sayville, N. Y.	C. M. Rogers					0	0		
Aug. 7	Aberdeen, Wash.	Hoh Camp. Willapa Logging Co.					2	0		
Aug. 7	Joliet, Ill.	Public Service Co. of Northern Ill.		Water-tube			0	0		Mud drum exploded
Aug. 9	Clarksville, Tex.	Major's Sawmill	10:00 a.m.	Portable	40 hp.		7	0	$1000	Low water
Aug. 9	Laurel, Miss.	Toy Plant					0	0		
Aug. 9	Pittsburgh, Penn.	Steam Fire Engine					0	3		Steam gage exploded
Aug. 11	Danville, Ill.	David Price's Cannery					1	1		
Aug. 11	Chicago, Ill.	North American Bldg.	3:00 p.m.	Water-tube		250 b.hp.	1	1	nominal	Oil or other foreign matter on [illegible] of tube
Aug. 12	Kansas City, Kan.	Kansas City Packing Box Co.					0	0		Automatic check on steam line ruptured
Aug. 12	Toledo, Ohio	Citizens Ice Co.					1	0		
*Aug. 13	Syracuse, N. Y.	Halcomb Plant (Crucible Steel Co.)		Water-tube	125		[0	1		
Aug. 14	New Philadelphia, Ohio	James Wenger's Farm					1	1		
*Aug. 14	Philadelphia, Penn.	Philadelphia Rapid Transit Co.		Water-tube			0	0		
Aug. 14	Keene, N. H.	Beaver Mills					0	0		Stop valve ruptured
†Aug. 15	Hope Valley, R. I.	Locustville Woolen Co.	1:30 p.m.	Return tubular	85	60 hp.	0	1	$25	
*Aug. 16	Brithwaite, La.	Louisiana Pulp & Paper Co.	2:30 p.m.	Water-tube	125	250 hp.	1	0	$600	Forcing fires and poor circulation
*Aug. 16	Clowry, Mich.	Am. Boston Mining Co.		Water tube			0	0		
Aug. 16	Excelsior Springs, Mo	Excelsior Springs Ice & Storage Co.					0	0		
*Aug. 16	Chicago, Ill.	Gottfried Brewing Co.		Water-tube			1	0		
*Aug. 18	Chicago, Ill.	Grand Pacific Hotel		Water-tube			0	0		
Aug. 19	Union, Miss.	Buntyn Sawmill					4	8		
Aug. 19	Brook, Ind.	Farm	4:30 p.m.	Locomotive type	120		1	0	$300	Carelessness
*Aug. 19	Dobbs Ferry, N. Y.	Manila Anchor Brewing Co.		Water tube			0	0		
Aug. 20	Pittsburgh, Penn.	Rankin Wire Works, U. S. Steel Co.					0	0		Cast-iron mud drum ruptured
*Aug. 21	Ashland, Ky.	Ashland Iron & Mining Co.		Water-tube			0	0		
Aug. 21	Cincinnati, Ohio	Robt. Mitchell Furniture Co.					0	1		Blowoff ruptured
Aug. 22	Rocky Point, Ore.	South Side Timber Co.		Donkey engine			0	1	nominal	Defective safety valve
Aug. 24	Providence, R. I.	Leggett's Drug Store		Hot water			0	5		
Aug. 25	Owasa, Iowa	Steinfeldt Farm	8:30 a.m.	Traction engine			0	2		Defective safety valve
*Aug. 28	New Castle, Penn.	Carnegie Steel Co.		Water-tube			0	0		
Aug. 29	Pittsburg, Kans.	Nevins Coal Co. (No. 6 Mine)					0	0		
Aug. 30	Detroit, Mich.	Murphy Power Co.					0	0		
Aug. 30	Pittsburgh, Penn.	Tug "Alice"					9	6		
Aug. 30	Itasca, Tex.	Itasca Oil Mill	11:30 a.m.				4	0	$15,000	
Sept. 1	Sharpstown, Md.	H. G. Elzey & Sons		Vertical			1	4		Flue collapsed
Sept. 1	Roseau, Minn.	Norquist Bros. Threshing Outfit	6:00 p.m.	Threshing machine	115	20 b.hp.	1	3	$400	Safety valve stuck
Sept. 2	Ft. Wayne, Ind.	J. A. Moran Ice Co.					0	1		Tube failed
Sept. 2	New York, N. Y.	Schwartzchild & Sulsberger Co.					0	0		Two tubes and cast-iron header failed
Sept. 2	Millington, Md.	Canning Factory	7:30 p.m.	Upright		30 b.hp.	0	2	$75	Low water
*Sept. 4	Dunkirk, N. Y.	Brooks Wks. Am. Locomotive Co.					0	0		
†Sept. 5	Pelham, Ga.	Pelham Mfg. Co.					0	1		
*Sept. 6	Alabama City, Ala.	Standard Steel Co.		Water-tube	150	375 lb.	0	0	0	
Sept. 6	Cheyenne, N. D.	D. O. Ostby Farm	p.m.	Threshing machine			2	1		Failure of water column to show low water
†Sept. 7	Chicago, Ill.	People's Gas Light & Coke Co.					1	0		
Sept. 8	Davenport, Iowa	Linwood Quarries					1	0		
Sept. 9	East Steelton, Penn.	Semet-Solvay Co.		Water-tube			0	0		Cast-iron header failed
Sept. 9	Atlanta, Ga.	Southern Ry. Shops					0	2		
Sept. 9	Ecorse, Mich.	Worcester Salt Co.					0	0		
Sept. 9	Vermillion, S. D.	William Hope Farm	8:00 a.m.	Portable boiler		14 b.hp.	0	4	$25	Too much pressure for an old boiler
*Sept. 10	Ft. Worth, Tex.	Southern Cold Storage Co.		Water-tube	125		0	1		
Sept. 10	Toledo, Ohio	Reliable Laundry & Cleaning Co.					0	0		
*Sept. 10	Philadelphia, Penn.	Philadelphia Rapid Transit Co.					0	0		
Sept. 10	El Reno, Okla.	Trulock Ice Co.		Tubular	100	72"x16'	0	0	0	Fire sheet bagged
Sept. 10	Chicago Heights, Ill.	Chicago Heights Oil Mfg. Co.					0	0		
Sept. 10	Savannah, Ga.	Torpedo Boat Destroyer "Craven"	12:45 p.m.	Normand	240	2776 h.s.	4	2		Low water
†Sept. 11	Mexia, Tex.	Munger Oil & Cotton Co.					0	0		
Sept. 12	Oshawa, Ont.	Seymour Gas Co.	9:30 a.m.	Return tubular		42"x11½'	2	0	$20,000	Low water
Sept. 12	Stage, Miss.	J. S. Rushing Sawmill		Tubular	300	45 b.hp.	2	4	Small $200	Low water
Sept. 13	East Schodack, N. Y.	Merton Garrison					0	0		
Sept. 13	Dallas, Tex.	Dallas Coffin Co.					0	0		
Sept. 14	Waukegan, Ill.	Northshore Gas Co.		Water-tube			0	0		Headers ruptured
Sept. 15	Rahway, N. J.	Waclark Wire Co.					3	0		Steam receiver exploded
Sept. 15	Mt. Airy, N. J.	Mrs. Samuel Dayton		Hot water			0	0	$2000	
Sept. 15	Carleton, Mich.	Williams Bros. Canning Plant	3:30 p.m.	Horizontal tubular	100	150 b.hp.	0	2	Slight	(Mud drum connection failure)
Sept. 16	Bryant, S. D.	Munson Farm		Threshing machine			1	1		
*Sept. 17	New Haven, Conn.	Winchester Rep. Arms Co.					0	2		
Sept. 19	Clinton, N. Y.	Clinton Knitting Co.	1:00 a.m.	Horizontal tubular	75	45 b.hp.	0	0	$2000	Low water and heavily scaled fire sheet
*Sept. 20	Greenport, L. I.	Ulmer Ice Co.	7:00 p.m.	Water-tube	75	16'x6' 3"	0	1	$15	Deteriorated

*Tube failure. †Blowoff failure.

BOILER EXPLOSIONS DURING 1913—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	In-jured	Property Loss	Probable Cause
*Sept. 21	Ft. Wayne, Ind.	Ft. Wayne & Northern Ind.		Water-tube			0	0		
Sept. 21	Ecorse, Mich.	Worcester Salt Co.		Scotch marine			0	0		Furnace ruptured
Sept. 23	Ogden, Utah	Banner Canning Co.					0	0		
Sept. 23	Collingwood, Ont., Can.	Blackstock Bros. Dairy Farm	3:00 p.m.	Portable threshing		14 b.hp.	1	3	$200	Unknown
Sept. 25	Garrison, Ky.	Robert Carver's Mill		Locomotive type	110	16 hp.	0	1	$225	Thin place in boiler
Sept. 25	Anniston, Ala.	La Grande Lime Stone Co.					0	1		Blowoff failed
Sept. 26	Troy, N. Y.	Tug "William P. Dalton"					1	0		
Sept. 26	Albia, Iowa	Coal Mine					1	1		
Sept. 26	Terre Haute, Ind.	Terre Haute, I. & E. Traction Co.		Water-tube			0	0		Cast-iron mud drum ruptured
Sept. 26	Arkadelphia, Ark.	W. A. Jones Sawmill					0	4		
Sept. 26	Ecorse, Mich.	Worcester Salt Co.		Scotch marine			0	0		Furnace collapsed
Sept. 27	Bridgeton, N. J.	Clarks Sand Washing Plant					0	0		
Sept. 27	Bridgeport, Penn.	Dechant Construction Co.	1:00 p.m.	Vertical fire tube	75	25 b.hp.	0	3	0	Oily water for feed to boiler
Sept. 28	Hurdsfield, N. D.	Threshing Machine					0	0		
Sept. 28	Taft, Calif.	Tight Wad Oil Co.	12:00 .m				0	1		
Sept 29	Chaseley, N. D.	Albert Stein	5:00 p.m.	Locomotive type	100	25 hp.	0	4	$1500	Old boiler
Sept. 30	Toledo, Ohio	Toledo Brick & Tile Co.	5:00 p.m.	Return tubular	110	80 hp.	0	0	$200 approx.	Scale over fire, shell ruptured
Sept 30	La Fayette, Ind.	Opera House		Cast-iron sectional			0	0		
Sept. 30	Brier Hill	Brier Hill Steel Co.		Water-tube			0	0		Three tubes ruptured
Sept. 30	Wilkinsburg, Penn.	Wilkinsburg Bank					0	1		
Oct. 1	Newark, N. J	Public Service Corporation		Water-tube			0	2		Tube ruptured
*Oct 3	Milwaukee, Wis.	Plankington Plant Swift Co.		Water-tube			0	0		
Oct. 3	Baltimore, Md.	Guth Chocolate Co.		Internally fired			0	0		Furnace collapsed
Oct 3	Virginia, Minn.	Steam shovel					0	0		
*Oct. 3	Abbeville, S. C.	Abbeville Cotton Mills		Water-tube			0	0		
*Oct. 5	Cincinnati, Ohio	Merchants Ice & Storage Co.		Water-tube			0	0		
Oct. 5	Albany, N. Y.	Piano Factory					0	0		
*Oct. 6	Alabama City, Ala.	Standard Steel Co.		Water-tube	150	375 hp.	0	0	0	
Oct. 7	Wheeling, W. Va.	Wheeling Traction Co.	5:30 a.m.	Water-tube		125 b.hp.	0	0	$100	Acid in feed water caused a tube blowout
Oct. 7	Springfield, Minn.	Adolph Trebisch Farm		Threshing machine			0	6		
Oct. 8	Pittsburgh, Penn.	Union Ice Co. 2 Plant		Water-tube			0	0		Cast-iron header ruptured
†Oct. 9	Waelder, Tex.	D. M. Flower's Cotton Gin	3:00 p.m.		120	125 hp.	1	0	0	
Oct. 10	Sewanee, Tenn.	J. W. Light Sawmill	10:00 a.m.	Russell portable	80	25 hp.	2	0	$300	Safety valve overset or stuck
Oct. 10	Niagara Falls, N. Y.	Hooher Electro-Chemical Co.		Water-tube	115	200 hp.	0	0	Repairs	Cast-iron header ruptured
Oct. 10	Redwood Falls, Minn.	Farm					0	6		
Oct. 10	Miley, S. C.	H. W. Lightsey Sawmill	11:00 a.m.	Horizontal tubular	80	60″x16′	1	1		Valve between boiler and safety valve closed
*Oct. 11	Pittsburgh, Penn.	Estate of Jos. W. Arrott		Water-tube			0	0		
Oct. 12	New York, N. Y.	Apartment House 162nd St.		Cast-iron sectional			0	0		
Oct. 14	Boston, Mass.	Apartment House, No. 6 Follen St.		Cast-iron sectional			0	0		
†Oct. 15	So. Acton, Mass.	South Acton Woolen Co.	noon	Return tubular	100		0	0	$300	
Oct. 15	Schenectady, N. Y.	613 State Street	10:00 a.m.	Horizontal	11	4 type	0	1	$1200	Unknown
Oct. 16	Denver, Colo.	Colorado Packing & Provision Co.					0	1		Blowoff ruptured
Oct. 18	Chicago, Ill.	Steel Wedels Co., 151 S. Water St.		Cast-iron heating			0	0		
Oct 20	Norridgewock, Me.	Harris Danforth	12:30 p.m.	Locomotive type	120	15 hp.	1	0		Crownsheet stay rods failed
Oct. 20	Ranier Beach, Wash.	F. N. Richards Residence					0	0		
Oct. 20	Philadelphia, Penn.	Philadelphia Rapid Transit Co.		Water-tube			0	0		Flue failed
Oct. 20	Louisville, Ky.	Washington School		Cast-iron sectional			0	0		Cracked
Oct. 21	Lynn, Mass.	Troy Laundry					0	0		
Oct 21	Livingston, S. I.	Richmond Light & Ry. Co.	4:45 p.m.	Vertical water-tube	150	About 300 hp.	7	3	$12,500	Failure of bottom head
Oct 21	Midland, Ont., Can.	Manley Chew Sawmill	8:00 a.m.				2	3	$8000	
Oct. 21	Youngstown, Ohio	Consolidated Gas & Elec. Co.		Steam receiver			0	3	Small	Receiver head failed
Oct. 21	Scappoose, Ore.	South Side Timber Co.		Logging engine			0	1		
Oct. 23	New York, N. Y.	Apartment House 263 W. 153rd St.		Cast-iron sectional			0	0		
Oct. 23	Eusley, Ala.	Semet Solvay Co.		Water-tube			0	0		Cast-iron headers failed
*Oct. 23	Fremont, Neb.	Electrical and Water Works City		Water-tube			0	0		
Oct. 23	Brooklyn, N. Y.	Ridgewood Pumping Station		Water-tube		250 b.hp.	1	2	None	Defective tube
Oct 24	Davenport, Iowa	Linde Shoeshop					0	0		
Oct 25	Meyerstown, Penn.	J. B. Milland & Sons					0	0		
†Oct 27	Brooklyn, N. Y.	Borden Condensed Milk Co.					0	4		
Oct. 28	Detroit, Mich.	Packard Motor Co.					0	1		
Oct. 31	Bowling Green, Ohio	Pure Ice Co.	10:00 a.m.	Locomotive type	12	12 b.hp	1	0	$50	Failure of crownsheet staybolts
Oct. 31	Harrisburg, Tex.	C. L. Smith Oil Co.	5:00 a.m.				0	1		
Oct 31	Oil City, Penn.	McCandless Drilling Co.	10:00 a.m.	Locomotive type		25 b.hp.	1	0	$500	Low water
Oct. 31	Proviso, Ill.	William Ginger Mushroom Plant	8 a.m.	Cast-iron hot water		5 b.hp.	1	0		Ignorance or carelessness of attendent
Nov.	Munfordville, Ky.	J. M. Moss' Sawmill	8:00 a.m.	Locomotive type	125	12 hp.	0	0	$100	Low water
Nov. 4	Frazee, Minn.	Peter Schram Farm					1	2		
Nov. 4	Bryan, Tex.	Artesian Well	5:30 p.m.	Locomotive type	100	50 hp.	0	0	(Boiler only)	Old age, misuse and neglect
Nov. 4	Fond du Lac, Wis.	Y. M. C. A. Bldg.					0	0		
Nov. 10	Franklin, Ohio	Harding Paper Co. Rag Mill	5:20 p.m.				0	1	$30,000	
Nov. 11	Indiana Harbor, Ind.	Inland Steel Co.					3	0		
Nov. 11	Buffalo, N. Y.	Hoeffler Ice Cream Co.					0	1		
Nov. 11	Russell, Ark.	Henry Roetzel Sawmill	6:00 a.m.			60 b.hp.	4	0	$1200	Turning cold water into overheated boiler
Nov. 22	Iona Island, N. Y	Navy Arsenal					2	0		
Nov. 22	Louisville, Ky.	Seelbach Hotel					0	3		
Nov 22	Tulsa, Okla.	Public Service Corporation	a.m.				0	0		
Nov 25	Portland, Iowa	Eugene Crowell Farm	9:00 a.m.				0	1		Old boiler
Nov 26	Calumet, Mich	Finnish Lutheran Book Concern	a.m.				0	0		Low water
Nov 27	Philadelphia, Penn	Bergdoll Brewing Co.	p.m.				0	1		

*Tube failure. †Blowoff failure.

BOILER EXPLOSIONS DURING 1913—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Nov. 27	Rue, Ala.	Price Sawmill	a.m.	Tubular	100	50 b.hp	3	2	$200	Pumping water into empty boiler
Nov. 30	Calais, Me.	St. Croix Opera Block		Hot water		38" fireproof	0	0	$50	Too hot fire made steam
Dec.	Mason City, Iowa						0	1		
Dec.	Chicago, Ill.	Chicago Distillery					4	0		
Dec. 1	Brooklyn, N. Y.	Standard Oil Can Factory					1	0		
Dec. 1	Boston, Mass.	Jefferson Bldg					0	0		
Dec. 4	Pittsburgh, Penn.	Brown & Co	4:00 p.m.	Upright water tube	120	150 b.hp.	0	0	$1500	Bursted tubes
Dec. 5	Albany, N. Y.	Enterprise Fire Co. Plant					0	0		
Dec. 6	Waco, Tex.	Texas Power & Light Co					0	3		
Dec. 8	Rocky Ridge, Pa.	Beck & Vo	10:30 p.m.	Locomotive type	120	25 hp.	0	0	$400	Safety valve stuck
Dec. 9	Derby, Penn.	East Fourth St.					0	1		
Dec. 9	Philadelphia, Penn.	O. D. Wilkinson, 2010 Walnut St.	a.m.	Hot water	0		0	0	1 Section	Boiler full and valves closed when fire was built
Dec. 12	Norwich, Conn.	Shore Line Electric Ry. Co.	5:00 a.m.	Water-tube	155	250 b.hp.	0	0	0	(Tube blowout) due to failure of weld
Dec. 12	Ellisburg, Ky.	Gassberry Sawmill	p.m.				0	2		
Dec. 13	Jersey City, N. J.	Patterson-Alnen Co.					0	1		
Dec. 13	Wilmington, Del.	Boston Clothing Store					0	0		
Dec. 14	Arlington Center, Mass.	Arlington Gas Light Co.					1	2		
Dec. 15	Brookline, Mass.	Apartment House					0	11		
Dec. 15	Lockhart, Ala.	Jackson Lumber Co.					1	2		
Dec. 16	Sisterville, W. Va.	Boiler Works					1	1		
Dec. 16	Nashville, Tenn	Harcourt Apartments						0		
Dec. 16	Lockhard, Ala	Jackson Lumber Co					1	2		
Dec. 16	Chicago, Ill	Harcort Apartment, 1375 E. 57th					1	0		
Dec. 18	W. N. Brighton, N. Y.	Interborough Garage					0	2		
Dec. 19	Brooklyn, N. Y.	Sands St. Memorial M. E. Church					0	0		
Dec. 19	Fritchton, Ind.	Andy Steffy Farm	9:00 a.m.				0	0		
Dec. 19	Highway, Ky.	Smith Bros. Sawmill	4:00 p.m.	Locomotive type	120	30 hp.	1	3	$600	Mud in the boiler
Dec. 20	Fertigs, Penn.	C. P. Irwin	1:00 a.m.	Locomotive type		25 b.hp.	0	0	$300	Valve closed between safety valve and boiler
Dec. 21	Bismarck, Mo.	Banie Iron Co. Sawmill		Drilling outfit			1	2		
Dec. 22	Greenville, Penn.	Greenville Elec. Lt., Ht. & Pr. Co.	p.m.				0	1		
Dec. 24	Richmond, Ind.	Standard Oil Plant					0	1		
Dec. 26	Toledo, Ohio	Mrs. P. Relzeke's House					0	3		
Dec. 28	New Haven, Conn.	97 Chapel St.					0	0		
Dec. 28	Ellicottville, N. Y.	Holy Name Church					0	0		
Dec. 28	Utica, N. Y.	W. A. Semple's Store	12:03 p.m.	Domestic hot water			0	0	0.50	Frozen pipe connection
Dec. 30	Pittsburgh, Penn.	406 Westminster St.					0	0		
Dec. 30	Brookville, Ind.	William Craig Traction Engine	2:00 p.m.	Peerless	105	10 hp.	0	1		Cold water and weakness of boiler

Mechanical Engineers' Spring Meeting

The spring meeting of the American Society of Mechanical Engineers was held, a couple of weeks later than usual, at St. Paul and Minneapolis during the week commencing June 15. The registration was one short of 400 and the meeting from all standpoints a decided success.

At its opening session the Society was welcomed to Minnesota by Governor A. O. Eberhardt and Max Toltz, chairman of the local committee, the response for the Society being made by Vice-President H. L. Gantt in the absence of President Hartness who was at New Haven receiving the honorary degree of Master of Arts from Yale University. Remarks were also made by Paul Doty of the local committee and others.

At the business meeting on Wednesday forenoon the report of the Committee on Pipe Flanges was discussed. "Power" readers are familiar with the attempt of the Mechanical Engineers, the National Association of Master Steam and Hot Water Fitters and other societies to establish a uniformity of practice in this particular, which resulted in the "U. S. 1912 Standard" and the promulgation by dissenting manufacturers of the "Manufacturer's Standard." At a conference on March 20 of this year, these differences were reconciled and a mutually acceptable schedule agreed upon, but a conflict of opinion, and interest has developed regarding the name by which the schedule shall be known. The National Association of Master Steam and Hot Water Fitters, who originated the movement and who have been particularly aggressive in carrying it through, hold that they are entitled to the prestige, which will come with the recognition of the fruition of their efforts by the retention of the designation of the schedule for which they have contended with a simple change of date, and urge that the successful schedule be termed the U. S. (United Societies) standard of 1915. Others contend that the modification of this standard should be emphasized by giving it a distinctive title and wish to call it the "American Standard of 1915". The case of the Master Steam and Hot Water Fitters was ably presented by Messrs. Childs and Denning and it was voted to refer the choice of a name to a committee made up of a representative of each society interested.

The interest of the business session centered in the report of the Committee on Standard Boiler Specifications. This committee was appointed, not as some maintain simply to evolve a blueprint of a standard horizontal tubular boiler, but to report to the Council recommendations bearing upon the situation brought about by the adoption of conflicting laws by various states and municipalities regarding the construction and operation of boilers and other pressure vessels. They have prepared a tentative report suggesting a form of law, which may be universally adopted and rules, following closely those of Massachusetts and Ohio regarding the design and proportions of such vessels and other appliances. Nearly two thousand copies of this tentative report have been sent to specialists for criticism and suggestion and its discussion was looked forward to with much interest. Following a meeting of the Council, an announcement was made that no discussion of the report in detail would be permitted at this meeting, but that its consideration would be limited to remarks upon the broad subject by representatives and the committee. Thomas Durban on behalf of the organized boiler manufacturers and Dr. Jacobus on behalf of The Babcock & Wilcox Co., urged immediate action. Mr. Durban said that his association had presented the situation to the governor and leaders of legislatures in every state that action in many states was imminent, and threatened, if the Society did not take immediate steps to suggest and direct legislation of this sort, that it would be done by his own organization.

Mr. Carhart of the Association of Steel Manufacturers said that his constituents were ready to furnish the boiler manufacturers with material practically and commercially adapted to their requirements, but that the requirements of the committee were excessive and commercially impracticable. In passing it may be said that there had been a conference between representatives of the boiler makers, the steel manufacturers, and the committee on Monday in which the boiler makers and the committee had taken the ground that being purchasers they were the judge of what they wanted and should be furnished with it if they were willing to pay the price.

The steel manufacturers maintain that steel of 0.3 to 0.5 per cent. manganese, 0.3 per cent. phosphorus and 0.03 per cent. sulphur is too difficult to make and unnecessarily good for boiler work, and claim that they must be allowed to sell the boiler makers both firebox and flange steel, as the latter affords an outlet for the rejecta of the former grades.

It was decided that the committee should give a public hearing, to which all parties in interest should be invited, at the United Societies Building in New York on September 15. Those desiring to present criticism, argument and suggestion shall present it in writing not later than August 15. An attempt to include representatives of other societies with voting power was overwhelmingly defeated.

The professional session of Wednesday morning was devoted to the discussion of Pulverized Coal, its use in the cement industry being described in a paper by Dr. R. C. Carpenter, for steam making in a paper by F. R. Low, and its use in industrial furnaces in a paper by W. S. Quigley. Abstracts of these papers and their discussion will appear in later issues.

Other papers of interest to "Power" readers presented at this meeting, and which will receive further attention in our columns are: "Classification and Heating Value of American Coals," by William Kent; "A Flow Metering Appliance," by A. M. Levin; "Power Development at the High Dam between Minneapolis and St. Paul," by Adolph F. Meyer, and "The Handling of Coal at the Head of the Great Lakes," by G. H. Hutchinson.

On Wednesday evening John Hearding, superintendent of the Oliver Iron Mining Co., gave an interesting lecture illustrated by moving pictures upon mining methods and ore handling.

Thursday's session was held at the University of Minnesota at Minneapolis, where addresses of welcome were delivered by President Snyder of the Board of Regents and H. T. Eddy, Dean of the Engineering College.

In the afternoon the society was entertained by Gebhard Bohn at his estate on Lake Minnetonka.

Friday was devoted to visits to industrial establishments, power plants, etc., a large number of members going to Duluth. Under the escort of local members they were given a moonlight excursion about the harbor on Friday evening, and on Saturday another excursion by steamer to the new works of the Minnesota Steel Company now under construction.

Kentucky N. A. S. E. State Convention

From June 3 to 5 the engineers of Kentucky held their 12th annual convention in Louisville. The headquarters of the exhibitors was in Liederkranz Hall, and with the exception of the first meeting the engineers conducted their business in Odd Fellows Hall, the regular meeting place of No. 1. Fully 90 engineers were registered, and 34 companies displayed an unusually good exhibit.

Wednesday was given over to a reception in the parlors of the Hotel Watterson to delegates and visitors, and in the evening Kentucky No. 1 treated the boys to a boat ride on the Ohio River. Music, dancing and refreshments added to the pleasure of the trip.

On Thursday forenoon the convention was opened in the exhibit hall by Charles Fertig, chairman of the local committee. Louis Stein, secretary of the mayor, welcomed the delegates to the city and a witty response was made by State President Carroll. J. H. Saunders, president of the commercial club, spoke of Louisville's growth and business, and urged the engineers to call on the club for anything that lay in its power to give. Robert W. Larkin, general manager of the "National Engineer," responded in his usual forceful style.

R. W. Brown, of the Convention and Publicity League, made a plea for Louisville as the annual convention city. He complimented the state organization on its success. It was a day of coöperation in which men must get together, exchange ideas and help each other in every way possible. F. L. Ray, vice-president of the national body, responded and delivered an eloquent address. He spoke at length on the purposes and plans of the National Association of Stationary Engineers and of the great value of the educational work conducted. No one is more responsible than the engineer for the health and happiness of the people at large, and it should be his earnest endeavor to make himself worthy of the trust. Every engineer should give more time to his own advancement and in this way reflect credit on the national organization. There is a great future for the engineer, and if the members will take advantage of the opportunities offered, the association will soon become the supreme factor in engineering progress.

In behalf of the Central States Exhibitors' Association President Cullen spoke briefly, calling attention to the exhibits and requesting an inspection by the engineers, their superintendents and managers and the public men of the city. The convention was then turned over to State President Carroll. Before adjournment the usual committees were

Delegates and Supply Men at the Kentucky N. A. S. E. State Convention, June 3-5, 1914 appointed and the exhibit was formally opened by Mr Cullen.

In the afternoon the first business session was held. Reports by the treasurer, secretary and various committees were followed by a short talk on the "Relation of Stationary Engineers to the Boiler Inspector," by L. Z. Brainard, manager of the St. Louis district for the Travelers' Insurance Co. R. E. Larkin spoke on "Our Paper," giving an insight into the cost of producing it and the possibilities of the future, providing it was given the earnest support of the various members of the association.

A smoker tendered the engineers by the exhibitors was the feature of the evening. Charles Cullen was the jovial toastmaster of the affair and was ably assisted by Messrs. Fiske, Wunder, Jones and Stout. Delegates from the various locals were also called to the rostrum to entertain by song or story.

At the second business session on Friday morning, Lexington was chosen as the next convention city. A paper dealing with the dry vacuum pump was read, there was also considerable discussion on the educational work of the associations. Members from the various locals told what their respective lodges had been doing. It was the consensus of opinion that the elementary courses should be given more attention. At least, they should be taken up before attempting the more technical studies on flue-gas analysis and kindred subjects. For the younger men the simple, practical work of the engine room, such as setting valves and keeping records, was recommended.

The following officers were elected: State president, G. J. Jake, Hopkinsville; vice-president, C. F. Moore, Lexington; secretary, August Pohl, Louisville; treasurer, L. N. Lowrey, Hopkinsville; conductor, R. V. Cason, Central City; doorkeeper, W. G. Russell, Henderson. C. Carroll, retiring president, was recommended to the national body as state deputy.

The afternoon was well spent in a visit to the High Street power station of the Louisville Ry. Co., and to the Crescent Hill pumping and filtering station. In the evening the National Tube Co.'s lecture, "From Ore to the Finished Tube," illustrated by motion pictures, was given by W. A. Phillis, of Pittsburgh. There was a good attendance to hear and appreciate the closing feature of the program.

Following is a list of the active members of the Central States Exhibitors' Association, who were represented and had exhibits: American Steam Gauge & Valve Co., The V. D. Anderson Co., Crandall Packing Co., Dearborn Chemical Co., The Garlock Packing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Home Rubber Co., Jenkins Bros., H. W. Johns-Manville Co., Keystone Lubricating Co., The Lunkenheimer Co., H. Mueller Co., "National Engineer," The Perolin Co. of America, William Powell Co., "Power," White Star Refining Co.

Associate members exhibiting were Ahrens & Ott Mfg. Co., The James Clark, Jr., Electric Co., Andrew Cowan & Co., Hafer Foundry & Machine Works, Indian Refining Co., The Jenkins Graphite Lubricating Co., Laib Co., Louisville Sanitary Wipers Co., Henry H. Martin Manufacturing Co., Moran Flexible Steam Joint Co., E. D. Morton & Co., W. H. Neill Co., Peerless Rubber Manufacturing Co., United States Graphite Co., Henry Vogt Machine Co., Harry S. Wood Co.

Those contributing but not showing their products were A. J. Anderson Co., Childens & Waters Co., Southern Manufacturers & Supply Co., Standard Oil Co.

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Iowa N. A. S. E. State Convention

At Des Moines, on June 3 to 5, the Iowa state convention was a decided success. The attendance was large, the exhibits good and the program excellent. Headquarters were at the Savoy Hotel. The exhibits occupied the entire main floor of the Des Moines Auditorium and the sessions were held in the assembly room of the same building.

At 1:30 Wednesday the first session was called to order by State President John Devine. Mayor Hanna welcomed the engineers to the city, and was followed in a brief address by Hon. G. W. Clarke, governor of Iowa, who highly commended the educational work conducted by the association. Fred W. Raven, national secretary, responded. The convention adjourned to inspect some of the power plants of the city, and in the evening the engineers were entertained at White City, Des Moines' amusement park.

On Thursday morning State Commissioner Warren Garst addressed the convention on the "Workmen's Compensation and Employers' Liability Law," and in the afternoon an interesting lecture on "The Burning of Iowa Coal" was delivered by Prof. W. H. Meeker, of Ames College. He showed how the native coal could be used to advantage by mixing it with Illinois coal, and suggested how some of the objectionable features in its burning could be eliminated. It was Prof. Meeker's opinion that the efficiency problems of the future would be worked out in the boiler room. Intelligent firemen should, therefore, be employed, and their wage should equal that paid engineers.

In the evening an athletic carnival featured by a "battle royal" was followed by an old-fashioned Dutch lunch.

At the business meeting Friday morning agitation was made for a state license law. Des Moines, Sioux City and Waterloo now have local laws and Clinton and Davenport engineers have been carrying on a vigorous campaign to get similar measures passed in their respective cities. A fund accumulated for the purpose will be used to further a campaign for a state license law before the next legislature.

F. H. Faas, of Cedar Rapids, then read a paper on the "Operation and Care of Steam Turbines." At the afternoon session a paper on "Stuffing a Cylinder Head" was read by Lafayette Young, Sr. The last business session followed, in which Clinton was chosen as the next convention city.

The following officers were elected:

J. A. Goddard, president; E. O. Landis, vice-president; Abner Davis, secretary; F. P. Boone, treasurer; A. C. Garrison, conductor; C. C. Ranzan, state deputy.

In the evening a three-reel motion photo showing the

Delegates and Guests at the Iowa State N. A.

manufacture of boiler tubing from the ore to the finished product was greatly appreciated. Following is a list of the exhibitors:

THE EXHIBITORS

Quaker City Rubber Co.
Hawkeye Compound Co.
Carbon Coal Co.
Griscom-Russell Co.
Greene, Tweed & Co.
Valvoline Oil Co.
Western Valve Co.
Anchor Packing Co.
Dearborn Chemical Co.
Murray Iron Works
George B. Carpenter Co.
Western Boiler Compound Co.
Manhattan Oil Co.
National Tube Co.
McGraw Co.
Jenkins Bros.
Mills-McCanna Co.
Crane Co.
Garlock Packing Co.
Mark Manufacturing Co.
H. W. Johns-Manville Co.
Globe Machinery & Supply Co.
Crandall Packing Co.
Iowa Electrical Supply Co.
Keystone Grease Co.
Viscosity Oil Co.
Lunkenheimer Co.
V. D. Anderson Co.
Highland Park College
Iowa Machinery & Supply Co.
Herf & Frericks Chemical Co.
Standard Oil Co.
"National Engineer"
Fisher Governor Co.
National Ammonia Co.

Kansas State Convention N. A. S. E.

On June 3 to 5, Kansas engineers held their second annual convention at Atchison. The official headquarters were at the Byram Hotel, the business sessions were held in the audi-

State Convention Group at Atchison, Kansas

S. E. Convention, Des Moines, June 3 to 5, 1914 [illegible] of the Atchison high school and the exhibit in Turner Hall.

Mayor Fitney delivered the address of welcome, and the response was made by L. E. Weaver, state president of the association. Mr. Weaver dwelt at some length on the mutual benefits to be derived from state license laws by both engineers and employers. W. J. Bailey, a former governor of Kansas, talked along efficiency lines and the work of the engineer. Willard Morris, chairman of the local committee, then turned over the meeting to President Weaver, who appointed the usual committees.

At noon the exhibits at Turner Hall were formally opened. In the afternoon the session was devoted to business. Thursday morning Fred W. Raven spoke of the advantages of a state license law and at the afternoon session Hon. Sheffield Ingalls, lieutenant-governor of Kansas, and William Washer addressed the meeting. In the evening N. T. Veach, superintendent of public schools, delivered a lecture, with lantern slides, on the "Panama Canal."

On Friday officers were elected and installed, the conventioners were treated to a sight-seeing tour over the city, and in the evening the convention was brought to a close with a banquet at the Byram Hotel.

"The Managing Engineer"—This is a new English monthly magazine devoted to the welfare of managers and chief engineers throughout the United Kingdom. It will publish all papers read before the engineering associations and invites free discussion of questions of moment to the engineer. The magazine is the official organ of the London Association of Foremen Engineers, and the Leeds Association of Engineers, and is negotiating with other large associations to that end. "Power" congratulates Thomas Tofts, its publisher on its excellent appearance and believes it will find a wide use in its field.

TRADE CATALOGS

Lunkenheimer Co., Cincinnati, Ohio. Booklet. "Renewo" valves. Illustrated, 12 pp., 3½x6 in.

Sprague Electric Co., 527-31 W. 34th St., New York. Pamphlet No. 905. Illustrated, 32 pp., 4x9 in.

Buckeye Engine Co., Salem, Ohio. Bulletin No. 111-B. Buckeye-mobile. Illustrated, 16 pp., 8x10½ in.

The Kelly & Jones Co., Greensburg, Penn. Catalog M. Pipe fittings, valves, etc. Illustrated, 444 pp., 5x7½ in.

Detroit Leather Specialty Co., Inc., Detroit, Mich. Catalog. Wear Well leather packings. Illustrated, 20 pp., 6½x9½ in.

Reeves-Cubberley Engine Co., Trenton, N. J. Catalog No. 17. Reeves steam engines. Illustrated, 36 pp., 8x10½ in.

Bury Compressor Co., Erie, Penn. Catalog No. 44. Air and gas compressors, vacuum pumps. Illustrated, 40 pp., 6x9 in.

The Smith Gas Producer Co., Lexington, Ohio. Catalog No. 9. Gas producers for bituminous coal. Illustrated, 26 pp., 6x9 in.

Brown Hoisting Machinery Co., Cleveland, Ohio. Catalog D. Tramrail systems, trolleys, electric hoists. Illustrated, 64 pp., 6x9 in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 34-C. Gasoline driven air compressor. Illustrated, 16 pp., 6x9 in.

Wm. B. Scaife & Sons Co., Pittsburgh, Penn. Bulletin. Underground gasoline storage outfits and welded tanks. Illustrated, 12 pp., 6x9 in.

American District Steam Co., North Tonawanda, N. Y. Bulletin No. 133. Atmospheric system of steam heating. Illustrated, 30 pp., 6x9 in.

Enell-Smith Manufacturing Co., Newark, N. J. Catalog. Lippincott indicators, for steam and gas engines, ammonia compressors. Illustrated, 7x9 in.

Edge Moor Iron Co., Edge Moor, Del. Bulletin No. 53. "High Boiler Efficiency with Low Grade Coal." Tests of a four-pass boiler with Illinois coal. Illustrated, 20 pp., 6x9 in.

Link-Belt Co., Chicago, Ill. Advance Section A, General Catalog No. 110. Original Ewart detachable link belt and sprocket wheels. Illustrated, 110 pp., 6x9 in. Book No. 190. Wagon and truck loaders. Illustrated, 32 pp., 6x9 in.

The Bristol Co., Waterbury, Conn. Bulletin No. 188. Recording differential pressure gages and recording flow-rate meters. Illustrated, 12 pp., 8x10½ in. Bulletin No. 189. Recording differential pressure gages and recording flow-rate meters, float type. Illustrated, 8 pp., 8x10½ in.

BUSINESS ITEMS

William Floyd Lee, chief engineer of C. W. Hunt Co., Inc., West New Brighton, N. Y., at a recent meeting of the board of directors, was elected vice president and chief engineer of the company.

The Erie City Iron Works, Erie, Penn., during the week of June 8th booked orders for 17 boilers, 9 engines and 20 tanks; on Monday, June 15, they received orders for two engines and nine boilers.

The Cleveland Electric Illuminating Co., Cleveland, Ohio, recently ordered thirty-one 2½-in. Simplex valves from the Yarnall-Waring Co., making five orders in two years from this company, totaling seventy-two 2½-in. valves.

The Terry Steam Turbine Co., Hartford, Conn., has just finished one of the largest months in the history of its business, in point of orders received. Additional machinery has been installed increasing the capacity of the plant about 25%.

On account of the growing volume of business the Skinner Engine Co., Erie, Penn., has found it necessary to run their works at night. In order to avoid the night work in future, they have contracted for a large extension of their shop buildings and also ordered the necessary new equipment.

E. W. Alderman, an experienced refrigerating engineer, who has been connected with the Vilter Manufacturing Co. for a good many years, has been appointed manager of the Pittsburgh district and will have his headquarters at 314 Curry Building, Pittsburgh, Penn. He succeeds H. W. Loecher, who has been transferred and will be located at the main office here in Milwaukee.

The C. & G. Cooper Co., Mt. Vernon, Ohio, is shipping two compressor units to the Columbia Gas & Electric Co.'s Branchland, W. Va., pumping station, which will deliver about 14,600,000 cu ft. of free gas per 24 hours against a pressure of 275 lb.—is building a 24x48 twin tandem compressor unit for the Logan Natural Gas & Fuel Co.—and has received orders from the Altoona Portland Cement Co., Altoona, Can., for a 21x30-in. single-tandem Cooper gas engine, and from the Marshall Field Estate for three Corliss engines.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Citizens Light, Heat & Power Co., Johnstown, Penn., contemplates constructing a central-power plant at Seward. P. J. Morrisey, Johnstown, is general manager.

The Bucks County Electric Co., New Hope, Penn., will construct an electric light and power plant. W. H. Janney, Newtown, is manager.

Bids will be received by the borough council, Tarentum, Penn., until July 13, for constructing a reinforced-concrete power house. Leo Hudson, House Bldg., Pittsburgh, is consulting engineer.

SOUTHERN STATES

The Columbus Power Co., Columbus, Ga., will install an additional 5000-kw. unit at the Goatrock station.

The Union Redrying Co., Lexington, Ky., is in the market for boilers for enlarging the capacity of its tobacco plant.

The C. Lee Cook Manufacturing Co., Louisville, Ky., is in the market for the following first-class and second-hand machinery: One 300 hp. or two 200 hp. water-tube boilers capable of 150 lb. steam pressure; two standard two-stage modern high-duty air compressor with 700 ft. free air capacity; one duplex 800-gal. fire pump; one 10 to- 15-kw. direct-connected direct-current engine, generator set, either 110 or 220 volts, the latter preferred; one standard gage saddle-tank locomotive capable of 140 lb. steam pressure with about 12-in. cylinders; one 600 hp. wet vacuum pump, duplex and fly-wheel type preferred, and one standard gage locomotive crane with approximately a 30-ft. boom and 10-ton capacity.

The Purified Petroleum Products Co., Louisville, Ky., is in the market for a 20-hp. motor, pumps and other equipment for a new plant which it will erect in the immediate future. G. A. Shaw, Louisville Trust Bldg., is in charge.

The Patterson Sand Co., 2615 Crop St., Louisville, Ky., is in the market for a motor-driven hoist, with drum and wire cable.

The Houston Electric Co., Houston, Tex., contemplates spending $2,000,000 for improvements to its plant.

The Louisville Gas & Electric Co., Louisville, Ky., contemplates spending about $400,000 for the construction of an extension to its plant on Washington St.

The Dayton Light & Power Co., Dayton, Tex., which has been recently organized, will construct an electric-light and power plant at Dayton. A. E. Kerr is interested.

The electric-light plant of the Taft Gin & Oil Co., San Antonio, Tex., which was recently destroyed by fire, will be rebuilt.

WEST OF THE MISSISSIPPI

Bids will soon be received for the construction of a municipal electric-light plant at Hills, Minn. Earl D. Jackson, Capitol Bank Bldg., St. Paul, is consulting engineer.

WESTERN STATES

The city of Nehalem, Ore., contemplates constructing a municipal electric-light plant.

The City Electric Co., San Francisco, Calif., will construct a substation a Harrison and Haywards Sts., to cost $15,000, exclusive of equipment. E. W. Beardsley is general superintendent.

The Pacific Gas & Electric Co., San Francisco, Calif., will build a concrete power station at Eighth and Minna Sts. John A. Britton is vice-president and general manager.

CANADA

Bids will be received by the city secretary-treasurer, P. J. Stephens, Estevan, Sask., until July 1, for furnishing and installing two 250-kw., 2300-volt, three-phase, 60-cycle, alternating-current generators, two exciters, one 500-kw. 2000-volt, three-phase, 60-cycle alternating-current generator and the necessary connections. S. G. Dethridge is engineer.

It is reported that the town of Prince Rupert, B. C., will install a municipal power plant to cost about $300,000.

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